Space Shuttle Launch Site

SPACE SHUTTLE LAUNCH AND RECOVERY SITE REVIEW BOARD

10 APRIL 1972

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1. SUMMARY

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Impact of Ballistic Booster Selection

The original Shuttle program called for a fully reusable, flyable booster (first stage) which took off as a rocket but landed as an airplane. The implications of a new operational plan and consequent new operational site prompted spokesmen in 40 states to request the location of the launch and landing site within their state. These suggestions when added to areas identified by NASA resulted in a total field of some 150 contending sites.

The recent selection of a ballistic (i.e., unguided), water-recoverable booster stage has, in effect, limited the feasible candidate sites to coastal areas. This decision also has led to methods of operation and site requirements very similar to those currently in effect at existing launch sites.

Screening to meet major mission and site requirements resulted in two final candidate options:

- A single, now virgin, Gulf-coast area (Matagoraa, Texas)
- The pair of existing east/west coastal sites (KSC/VAFB)

No existing single site could satisfy total program requirements.

Cost Studies

Detailed analyses were made to determine the total cost to the Government to establish facilities for Shuttle launch and landing operations. The analyses included launch vehicle and payload processing requirements, the configuration of range instrumentation, and personnel required to accomplish the entire launch and landing operation at specific sites. Results show there is no clear economic advantage to establishing a new single launch site with the capability to handle all Shuttle launches as compared to continued utilization of the two existing launch sites. The main reason for this result is that the ultimate reduction in annual operating cost for a single site is not sufficient in magnitude and is too far distant in time to overcome the large initial costs. At the same time, the single site appears not to offer the clear cut mission performance and operational capabilities that exist jointly in the two existing sites. The Gulf-coast site could be subject to greater restraints in its adaptability to meet the requirements of future programs and would involve the potentially complex problem of land acquisition. In view of the lack of a new site having performance or cost advantages, the Board's evaluation gave higher ranking to the pair of currently operated launch sites -- viz., Kennedy Space Center and the Vandenberg Air Force Base.

Detailed Evaluation Results

Kennedy Space Center has served as the launch site for large rocket vehicles and all manned missions for well over a decade. It thus has existing many of the facilities that the Shuttle program will require. This is shown in the low estimates for first costs at KSC compared to other sites. KSC has launch azimuths available which accommodate a large percentage of the planned missions. In particular, it has clear azimuths in the easterly direction which provide greatest margin for orbit insertion during the early development flights -- which may include an unmanned flight. VAFB can accommodate the polar and sun-synchronous mission traffic that cannot be launched efficiently from KSC. Most importantly, VAFB can accommodate westerly launch azimuths required to support Air Force missions.

Continuation of operations at KSC/VAFB would take advantage of existing facilities and services now shared by the civil and military programs; would incur minimum costs for maintaining expendable launch capability during the transition to the Shuttle program; and would minimize the possibility of disruption and other programmatic risks associated with moving to a new site. In view of NASA's decade of experience with Apollo and the Air Force's solid rocket experience with Titan, continued operation at KSC/VAFB also provides greater assurance that environmental and community impact of the program will be acceptable.

An initial review indicates a site in Matagorda County, Texas, has potential to accommodate much of the total program as a single site. Launches from this site would result in sub-orbital (though very high altitude) land overflight earlier in the trajectory than from the ocean facing sites. All due-east launches -- particularly the early development flights -- would overfly Florida. The focussed sonic boom of certain ascent trajectories could impinge on land unless performance degrading maneuvers are prescribed to avoid this. The sonic boom carpet of the orbiter return flight potentially covers the largest amount of land area in approaching this site.

Planned booster impact zones fall short of the major shipping lanes and current oil drilling platforms but could impede future development of the area. This review did not take into account the area requirements for abort jettison of H-O tanks. Additional operations planning is required to finalize these mission rules. In any event, greater freedom from land overflight is available at the ocean-facing sites. The precise location of a site in this area would have to consider the bird sanctuary near Matagorda Island. Additional data would be necessary to judge the community impact of building up a site in Texas and simultaneously phasing down the operations at KSC and VAFB. Acquisition of necessary land could introduce unpredictable complication and delay.

Special Topics

The report outlines the screening and evaluation of candidate sites prior to the requirement for water recovery. The full account of this process was not considered relevant to a report of the final evaluation. Briefly stated, it was judged that operation from an inland site, where potentially feasible at all, would impose unduly severe restrictions on the future course of the program. Normal launch operations, up to booster impact, require the availability of cleared areas of at least 2000 square miles for each launch azimuth. No such areas in the continental United States could be found with population densities less than about one per square mile.

The report also discusses environmental implications of site location -- particularly sonic boom, engine noise, and fuel exhaust. The selection of a coastal site would give greater assurance of acceptable environmental impact and would provide greater flexibility for beneficial placement of sonic boom footprints. As the evaluation was not restricted to sites on government-owned land, the report addresses the possibility of delays and adverse public reaction if land is to be acquired for the launch site.

In concluding remarks, the Board points out the cost and scheduling advantages of activating the East coast site first, if the dual-site option is selected.

2. INTRODUCTION

2.1 Establishment of the Board

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The Shuttle Launch and Recovery Site Review Board was established by letter of the Associate Administrator for Manned Space Flight (MSF) dated April 26, 1971. The final board membership was as follows:*

Dr. Floyd L. Thompson, Chairman
Director Emeritus, Langley Research Center

Maj. Gen. Edmund F. O'Connor
Dep. Chief of Staff, Procurement & Production
Headquarters, Air Force Systems Command

Mr. Vincent L. Johnson
Deputy Associate Administrator, OSS
NASA Headquarters

Mr. Robert H. Curtin
Director, Office of Facilities
NASA Headquarters

Mr. LeRoy E. Day
Deputy Director, Space Shuttle Program
NASA Headquarters

Mr. S. Neil Hosenball, Deputy General Counsel served as legal counsel to the Board and Dr. Dudley G. McConnell, Director of the Scientific and Technical Information Office, served as Executive Secretary.

The Associate Administrator, OMSF, assigned the Board responsibility for the review and evaluation of candidate launch and recovery sites for the Space Shuttle. The evaluation would then be a basis for site selection by the Administrator. The Board would prepare written and oral reports to the Administrator through the Associate Administrator for Manned Space Flight. Additionally, a set of Guidelines directed the Board to furnish its judgement on certain other aspects of the conduct and implications of the development program. The Charter and Guidelines are presented in Appendix A.

* Mr. Clarence C. Gay and Mr. Robert Lindley, original appointees, subsequently accepted other assignments which precluded their participation on the Board. Mr. Day was assigned by letter from the Associate Administrator (MSF) dated January 10, 1972.

2.2 Method of Operation

It was decided that the Board would make use of previous and concurrent studies by other elements within NASA rather than charter special study groups of its own. Primary among these existing groups were the Entry Aerothermodynamics Technology Working Group (Chaired by Mr. Fred Demeritte, OAST); its Sonic Boom Panel (Chaired by Mr. Paul Holloway, LaRC); the Shuttle Facilities Working Group (Chaired by Mr. Robert Curtin), and the Ralph M. Parsons Company, a contractor which worked under the direction of the Office of Facilities. The Board would also, as far as practicable, follow Source Evaluation Board procedures in the collection, handling and reporting of information.

2.3 Bases of Evaluation

2.31 Requirements

2.311 Basic Mission Requirements

The Space Shuttle Program must be able to deliver and to retrieve a variety of earth orbital payloads as outlined below:

- Automated Payloads
  - NASA
  - Non-NASA
  - DOD
- Manned Flights
  - Sortie
  - Space Station Logistics
  - Man-tended Experiment Modules

These payloads are distributed among multiple launch azimuths to accomplish as efficiently as possible a variety of orbital inclination/payload combinations as follows:

8)

Inclinations (see figure 2.1)

Low	- Civil & DOD
	- Planetary
High	- Space Station Supply and Experiment Modules
	- Earth Observations
Polar and Near Polar	- Scientific and Applications Missions
	- Unique DOD Missions

2.312 System Configuration

- Orbiter
  - External hydrogen/oxygen tank
  - Payload compartment: 15 ft diameter by 60 ft long
  - Payload to orbit (Up payload) capability
    - 65,000 lbs. launched due east to 100 n.mi. from baseline latitude of 28.5° N (KSC)
    - 40,000 lbs. south polar
    - 25,000 lbs. to 270 n.mi. 55° inclination orbit with the air breathing engine system in the payload compartment
  - Down payload 40,000 lbs.

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. Three high chamber pressure, liquid hydrogen - liquid oxygen engines with 470,000 lbs. vacuum thrust each

. Reusable external insulation thermal protection system

. Staging velocity of 4,000 to 5,000 ft/sec*

- Booster

Ballistic water-recoverable vehicle using solid rocket motors (SRM)

The Space Shuttle System to accomplish the mission/payload combinations as listed above is expected to have a gross lift off weight (GLOW) of 4.5 to 6 million pounds. In addition to the recovery and landing areas, a space vehicle system of this size and configuration is expected to require propellants, gases, clean rooms, ground support equipment, and processing facilities of the same general magnitude as that required for an Apollo Saturn V.

2.313 <u>Launch and Recovery Site Requirements</u>

The general launch and recovery site operational facility requirements for the orbiter and booster include the equipment and personnel to provide:

Launch Support

Maintenance

Logistics

Administration

* The figure presently contemplated for vehicle design. Long term requirements of the site were based on a range of 4,000 to 6,000 ft/sec

Utilities, Services, and Site Work

Orbiter Landing

Booster Recovery and Refurbishment

In addition to the operations site itself, the selected locale must afford:

- Buffer zones surrounding the site proper

- Unpopulated areas for booster impact and safe ascent aborts

- Remoteness from downrange populous areas to minimize overflight risks

- A supporting community

Vertical flight development and subsequent program operations are to be accomplished at the same site. The development phase will require:

- Tracking and data acquisition systems that will give detailed coverage during boost, separation, and orbiter ascent phases

- Sufficient space to permit safe abort procedures that will minimize hazard to the crew and populated areas

Particular site requirements used in the screening process (section 3) are:

- Orbiter flyback (i.e., landing field meeting standard FAA and DOD regulations)

- Booster impact in 20 fathoms of water from 100 up to 200 n.mi. down range along each launch azimuth

2.32 Evaluation Criteria

The Board agreed upon the following factors in judging the extent to which a site could accept the planned program and would have flexibility to accommodate a program beyond that currently foreseen.

- Mission Capability

  -- can mission requirements (payloads and orbits) be achieved with minimum degradation in vehicle performance

- Booster Recovery

  -- are adequate water area and depth available for recovery operations

- Abort Planning

  -- are safe impact zones available for emergency jettison of external tanks

  -- are ranges of launch azimuth available with acceptable overflight conditions

- Logistics Planning

  -- is there convenient access to modes of transport for Shuttle vehicles, power, and fuels

  -- does the site adopt well to overall Shuttle logistics planning

Environmental Factors

- Weather and Climate

  -- are weather conditions conducive to continuous operations

- Air and Water Quality

  -- can the local region accept this program with acceptable impact on air and water quality

- Noise

  -- are areas available for acceptable placement of ascent and orbiter return sonic booms

  -- are buffer zones available to assure acceptable engine noise levels in surrounding communities

- Community Impact

  -- would placement of the program significantly impede the pattern of community development

  -- could this program create interference with dedicated airspace or important local community activity

Programmatic Factors

- Costs

  -- does the proposed site offer the most economical means of meeting program requirements

  -- does the proposed complex of facilities lead to prudent use of the existing investment in launch facilities

- Scheduling

  -- can modification and site activation be accomplished to meet program requirements

  -- would activation of proposed facilities create disruption to on-going programs

2.33 Treatment of Weather & Climate Factors

Consideration was given to the bases of weather and climate and the frequency of lightning strikes as site evaluation factors. NASA has for over 10 years operated a worldwide tracking system -- with stations located in a wide range of climatic conditions. The Board leaned upon that experience to judge that local weather and climate were not discriminating factors among the final candidate sites, but would have some bearing on construction costs and maintenance of a facility.

Weather does affect the ability to work outdoors year round when that is a requirement -- as for example during construction. To that extent, weather and climate enter the evaluation as factors in cost and manpower requirements.

Recent Air Force studies[1] on lightning hazards to aircraft indicate that the probability of cloud to cloud lightning strikes is appreciable even in areas where and at times when the probability of ground strikes may be low.

Therefore, the probability of ground strikes did not enter as a factor in site evaluation. The hazards of lightning are to be considered in the Shuttle design through provision of sufficient safe conducting paths to guard against adverse effects of lightning strikes which may occur.

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2.34 Relationship of the Launch Site Selection to other Shuttle Site Decisions

In the judgment of this Board, the selection of a launch and landing site can be made independently of other site decisions of the Shuttle program.

Aside from the launch and landing site, the agency must select sites for manufacture and assembly of the booster and orbiter and for horizontal flight testing. The Board accepted the program office position that sufficient flexibility existed to transport the vehicle from candidate assembly sites to a coastal launch site. The decreased size of the orbiter makes its assembly feasible at many locales and, upon FAA approval, the orbiter could fly from its assembly site to the horizontal flight test site and to the launch site. Thus, the assembly sites and horizontal flight tdst site were not coupled to each other or to the launch landing site.

Requirements for the Shuttle operational site include an airport that would be planned to meet current FAA criteria. This airport will be suitable for orbiter hozizontal flights. It is not contemplated that special provisions that might be considered essential for development flight testing would be included. It is contemplated that such flight testing would be carried out at one of the existing aircraft flight test centers that have specialized capability for this type of program; for example, such centers as Edwards Air Force Base or the Navy installation at Patuxent, Maryland. During such tests, the aircraft will be powered by conventional jet engines so that no unusual fuel requirements will be involved.

REFERENCES

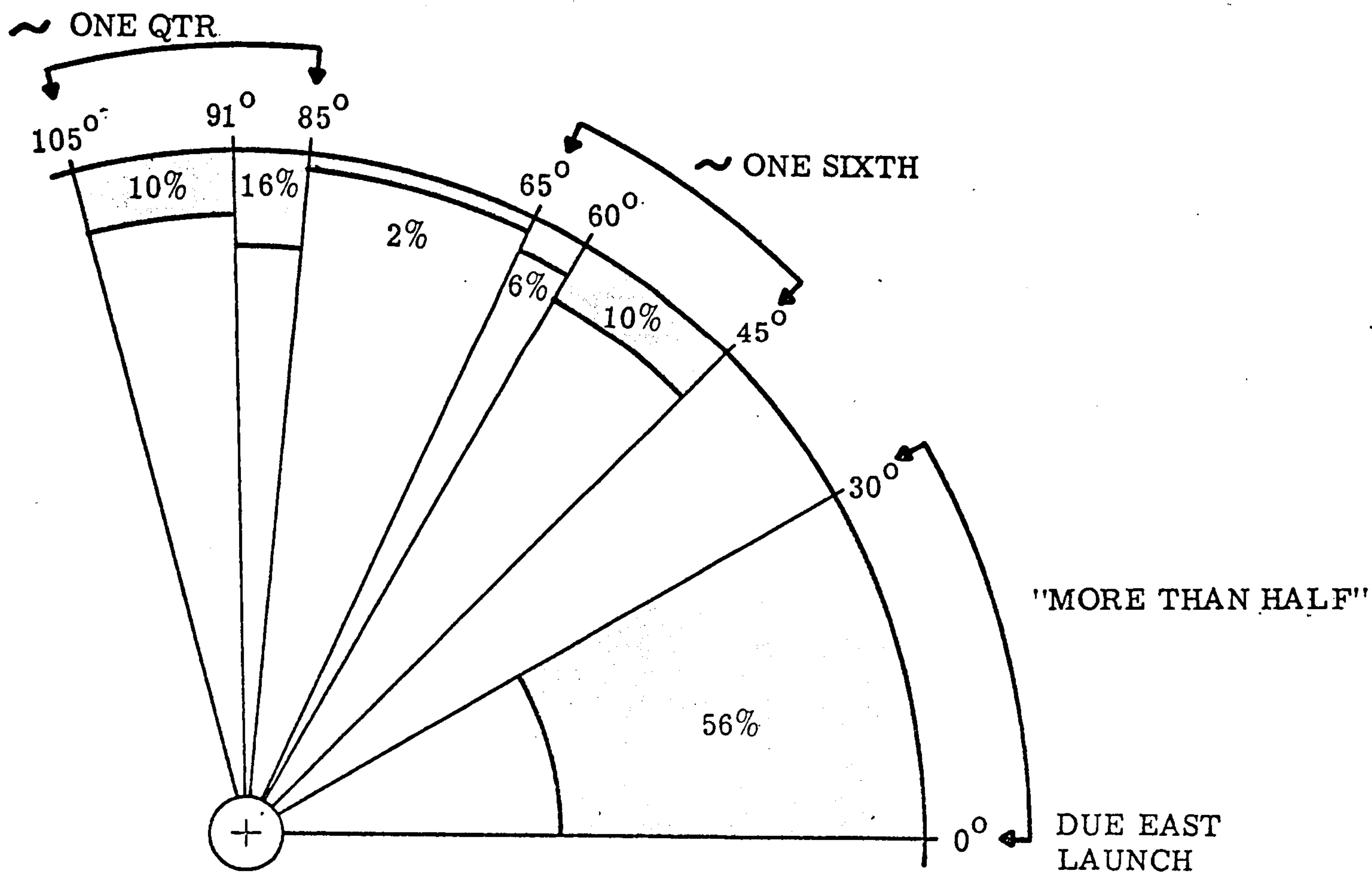
1. 1970 Lightning and Static Electricity Conference, 9-11 December. Air Force Avionics Lab and Society of Automotive Engineers, Dec. 1970.

2. Lightning Electrical Hazards to Flight Vehicles. Tech. Rept. AFAL-TR-69-269, Wright-Patterson Air Force Base, Ohio, and Naval Air Systems Command, Washington, D.C., Dec. 1969, by J. D. Robb, J. R. Stahmann, and L. A. Bochland.

3. Lightning and Static Electricity Conference, 3-5 December, 1968. Part II. Conference Papers. Tech. Rept. AFAL-TR-68-290, Pt. II, Air Force Avionics Lab., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1969.

SPACE SHUTTLE MISSION TRAFFIC

PERCENTAGE OF NASA/DOD PAYLOADS VERSUS ORBIT INCLINATION SECTORS



*SOME PAYLOADS MAY USE EITHER NORTH OR SOUTH INCLINATIONS.

FIGURE 2.1

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3. SITE SCREENING

3.1 Identification of Candidate Sites

When this Board was formed, the Shuttle system consisted of a manned flyable booster and a manned orbiter. The booster-orbiter combination was to take-off vertically as a rocket but both stages were to land as airplanes. In addition, planning called for "airplane-like" operation. These factors implied methods of operation and site requirements quite different from those which had prevailed up to that time at existing launch sites such as Kennedy Space Center and the Vandenberg Air Force Base.

NASA, as part of its overall Shuttle planning, sought an operations site which could fulfill the requirements of the new program at minimum cost. For example, a single site as opposed to the existing pair of launch sites. Spokesmen in 40 states requested NASA to locate the launch and landing site within their state. These requests -- some were multiple from the same state -- when added to those sites identified by NASA resulted in a total field of 150 sites for consideration. These sites are listed below.

3.2 Listing of Candidate Sites

STATE/LOCATION		SITE NUMBER
Alabama	CRAIG AFB	1
	MSFC/REDSTONE	2
Arizona	COCONINO PLATEAU	3
	DAVIS-MONTHAN AFB	4
	LUKE AF RANGE	5
Arkansas	BLYTHEVILLE AFB	6
	FT. CHAFFEE	7
California	CASTLE AFB	8
	CHINA LAKE NAS	9
	EDWARDS AFB	10
	MIRAMAR NAS	11
	OXNARD AFB	12
	PT. MUGU NAS	13
	VANDENBERG AFB	14
Colorado	LOWRY AFB	15
	PUEBLO	16
	BUCKLEY	17
Delaware	DOVER AFB	18
Florida	BARSTOW AFB	19
	EGLIN AFB	20
	KSC - ETR (PATRICK)	21
	MacDILL AFB	22
	PENSACOLA NAS	23
	TYNDALL AFB	24
Georgia	DOBBINS AFB	25
	HUNTER AFB	26
	MOODY AFB	27
	TURNER AFB	28
Idaho	CRATERS OF THE MOON	29
	NEAR AEC STATION	30
	MOUNTAIN HOME AFB	31
	BOISE COUNTY	31A
Kansas	FORBES AFB	32
	GARDEN CITY AREA	33
	HUTCHINSON/TOPEKA	34
	HAYS/RUSSELL	35
	GOODLAND	36
	SMOKY HILL AFB	37
Kentucky	FT. CAMPBELL	38
Louisiana	BARKSDALE AFB	39
	ENGLAND AFB	40
	LAKE CHARLES AFB	41
Maine	DOW AFB	42
	LORING AFB	43
	PRESQUE ISLE AFB	44
Maryland	PATUXENT NAS	45
Mass.	OTIS AFB	46
	WESTOVER AFB	47
Michigan	KINCHELOE AFB	48
	SELFRIDGE AFB	49
	WURTSMITH AFB	50
Mississippi	COLUMBUS AFB	51
	GREENVILLE AFB	52
	KEESLER AFB	53
Missouri	MALDEN AFB	54
	RICHARDS-GEBAUR AFB	55
	WHITEMAN AFB	56
Montana	GLASGOW AFB	57
	MALMSTROM AFB	58
Nebraska	AINSWORTH MUNI APRT.	59
	ALLIANCE MUNI APRT.	60
	BRUNING STATE APRT	61
	EPPLEY FLD. Omaha	62
	FAIRMONT STATE APRT	63
	GRAND IS MUNI APRT	64
	HARVARD STATE APRT	65
	LINCOLN MUNI APRT	66
	McCOOK STATE APRT	67
	OFFUTT AFB	68
	SCOTTSBLUFF MUNI	69
	SCRIBNER STATE APRT	70
Nevada	FALLON NAS	71
	INDIAN SPRGS AFB/RGE	72
	LINCOLN COUNTY	72A
	TONOPAH	73
	EUREKA COUNTY	73A
New Hampshire	PEASE AFB	74
New Mexico	CANNON AFB	75
	KIRTLAND AFB	76
	SANDOVAL COUNTY	76A
	WSMR/HOLLOMAN AFB	77
	WALKER AFB	78
New York	PLATTSBURGH AFB	79
	STEWART AFB	80
North Carolina	POPE AFB	81
	SEYMOUR-JOHNSON AFB	82
North Dakota	GRAND FORKS AFB	83
	MINOT AFB	84
	FARGO	85
	BISMARCK	86
Ohio	CLINTON CO. AFB	87
Oklahoma	ARDMORE AFB	88
	CLINTON-SHERMAN AFB	89
	MILL CREEK	90
	TINKER AFB	91
	VANCE AFB	92
Oregon	BOARDMAN SITE	93
	KINGSLEY FIELD	94
	LAKE COUNTY	94A
	AREA ONLY	95
Pennsylvania	OLMSTEAD AFB	96
South Carolina	DONALDSON AFB	97
	MYRTLE BEACH AFB	98
	SHAW AFB	99
South Dakota	ELLSWORTH AFB	100
Tennessee	SEWART AFB	101
Texas	AMARILLO AFB	102
	BERGSTROM AFB	103
	BIGGS AAF	104
	BIG BEND AREA	105
	BIG BEND ALT.	105A
	CAMERON CO.	106
	CARSWELL AFB	107
	CONNALLY AFB	108
	CORPUS CHRISTI NAS	109
	ELLINGTON AFB	110
	FT. HOOD	111
	GRAY AFB	112
	HARLINGEN AFB	113
	KELLY AFB	114
	LAREDO AFB	115
	LAUGHLIN AFB	116
	LUBBOCK	117
	MATAGORDA AF RGE	118
	MATAGORDA COUNTY	118A
	RANDOLPH AFB	119
	SHEPPARD AFB	120
	WEBB AFB	121
Utah	MICHAEL/DUGWAY	122
	MILLARD COUNTY	122A
	HILL AFB/RGE/DEPOT	123
	WENDOVER AFB/RGE	124
Vermont	ETHAN ALLEN AFB	125
Virginia	LANGLEY AFB	126
Washington	LARSON AFB	127
	McCHORD AFB	128
	PAINE AFB	129
Wisconsin	RICHARD BONG AFB	130
Wyoming	ALBANY CO.	131
	BIG HORN CO.	132
	SHERIDAN COUNTY	132A
	CARBON CO.	133
	CROOK CO.	134
	HOT SPRINGS CO.	135
	SUBLETTE COUNTY	135A
	JOHNSON CO.	136
	F. E. WARREN AFB	137
	NATRONA CO.	138
	PARK CO.	139
	WASHAKIE CO.	140

3.3 Impact of Configuration Definition

On March 15th, 1972, NASA selected a ballistic, water-recoverable, solid rocket booster and thus fully defined the Shuttle vehicle configuration. The OMSF determined the suggestions of guiding the booster to a pre-selected impact site and of land recovery to be unfeasible. Based upon Titan experience for normal launch dispersion, the Board judged that no inland body of water provided sufficient area for booster impact. (Except possibly the Great Lakes where community encroachment would preclude this program.) Thus further consideration was limited to coastal sites.

Up to that time, the Board had considered inland sites for use with an expendable booster option. A detailed account of that screening procedure was not considered pertinent to this report. (See Appendix B.) The conclusion was that because of the vast area required for impact of the unguided booster and for possible emergency jettison of the H-O tank, no inland site could be found which would provide more than just a few launch azimuths. No inland site could furnish launch azimuths for both easterly and polar launches. The Board judged it imprudent to so constrain the future course of this long-range program, as would be inherent in the selection of an inland site. Coastal sites afforded multiple azimuths and much greater flexibility to adapt to changes in the program.

3.4 Screening of Coastal Sites

Figure 3.1 shows the footprint used to determine available booster impact zones along launch azimuths from candidate sites. The figure also shows the ground trace of the focussed ascent sonic boom which the Board judged could not be placed on inhabited areas. The landing field requirements are shown in figure 3.2 by the FAA/DOD imaginary-surface layout. Finally, the site must include sufficient area for buffer zones to assure acceptable acoustic impact on surrounding communities. As explained in section 5.13, the Board used a sound pressure level of 115db at the boundary to size the site. This resulted in a requirement for about 64,000 acres of government controlled land at the site. These specific site requirements together with launch azimuth requirements (figure 3.3) were used to screen sites as follows:

- The west coast area -- except VAFB -- were eliminated because of terrain limitations and because existing community development would impede or prevent necessary land acquisition.

- The east coast north of Chesapeake Bay was eliminated because it was unlikely that the government would acquire sufficient land area for the site (i.e., existing community encroachment). Sites in North and South Carolina apparently had clear azimuths available. Closer investigation showed that the mainland areas had well established and growing resort communities; the islands were too small to accommodate the site.

Thus on each ocean coast only the two existing sites survived, and these sites each had limitations. Please refer to the maps in figures 3.4(a) and 3.4(b). VAFB could provide near polar and retrograde azimuths -- particularly for sun-synchronous applications missions and to support Air Force requirements. VAFB could not provide easterly launches. (Due-east launches are favored during development for they provide the greatest margin for orbit insertion.) KSC could provide the easterly azimuths vital to the development program and that carry the major portion of mission traffic. KSC could not, however, provide azimuths for polar or sun-synchronous orbits during the early phase of the program. Southerly headings would have booster impact on land. Northerly launches would incur suborbital land overflight by the orbiter shortly after staging.

The OMSF determined that, during the early development period, land overflight of the orbiter would be restricted; thus the most northerly heading at KSC would be about 35° east of north. To maneuver from such a heading into polar orbit would require too severe a payload penalty to accomplish many of the missions. Based on existing requirements, 10 to 15 missions a year could not be flown from KSC. Thus no single existing site could meet all program requirements.

Upon investigating the Gulf coast, an area was found in Matagorda County, Texas that had potential to accommodate much of the total program. This site apparently had cleared areas for booster impact and recovery and the area seemed sufficiently free of existing development to warrant further investigation. (See figure 3.5)

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To summarize, screening, in the wake of booster selection, resulted in two final site options:

- A single, now virgin, Gulf-coast area (Matagorda, Texas)
- The pair of east/west coastal sites (KSC/VAFB)

BOOSTER IMPACT FOOTPRINT

(WITH BOOSTER ASCENT FOCUSING SONIC BOOM)

BASED ON:

- TITAN III D ACTUAL EXPERIENCE
- SATURN V 3-SIGMA PROJECTION
- NORMAL LAUNCH & ASCENT
- NO WIND

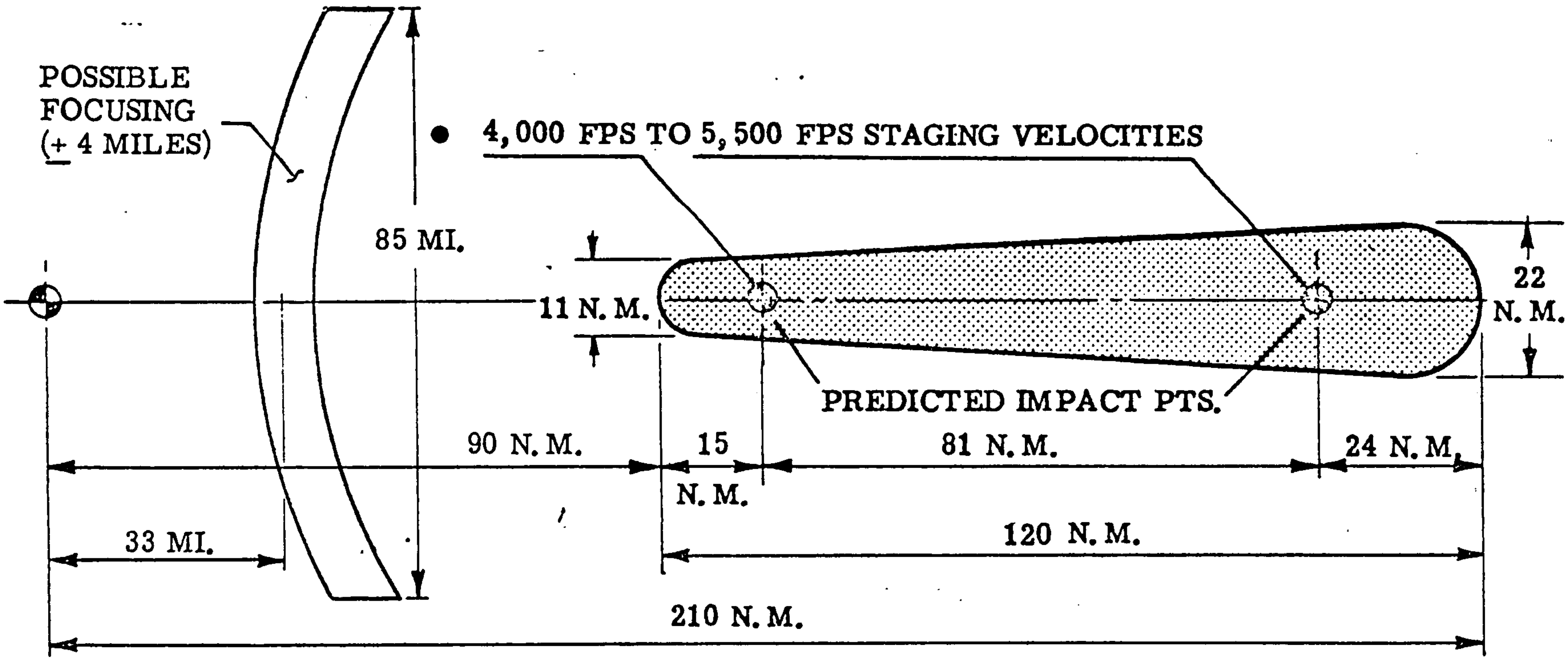
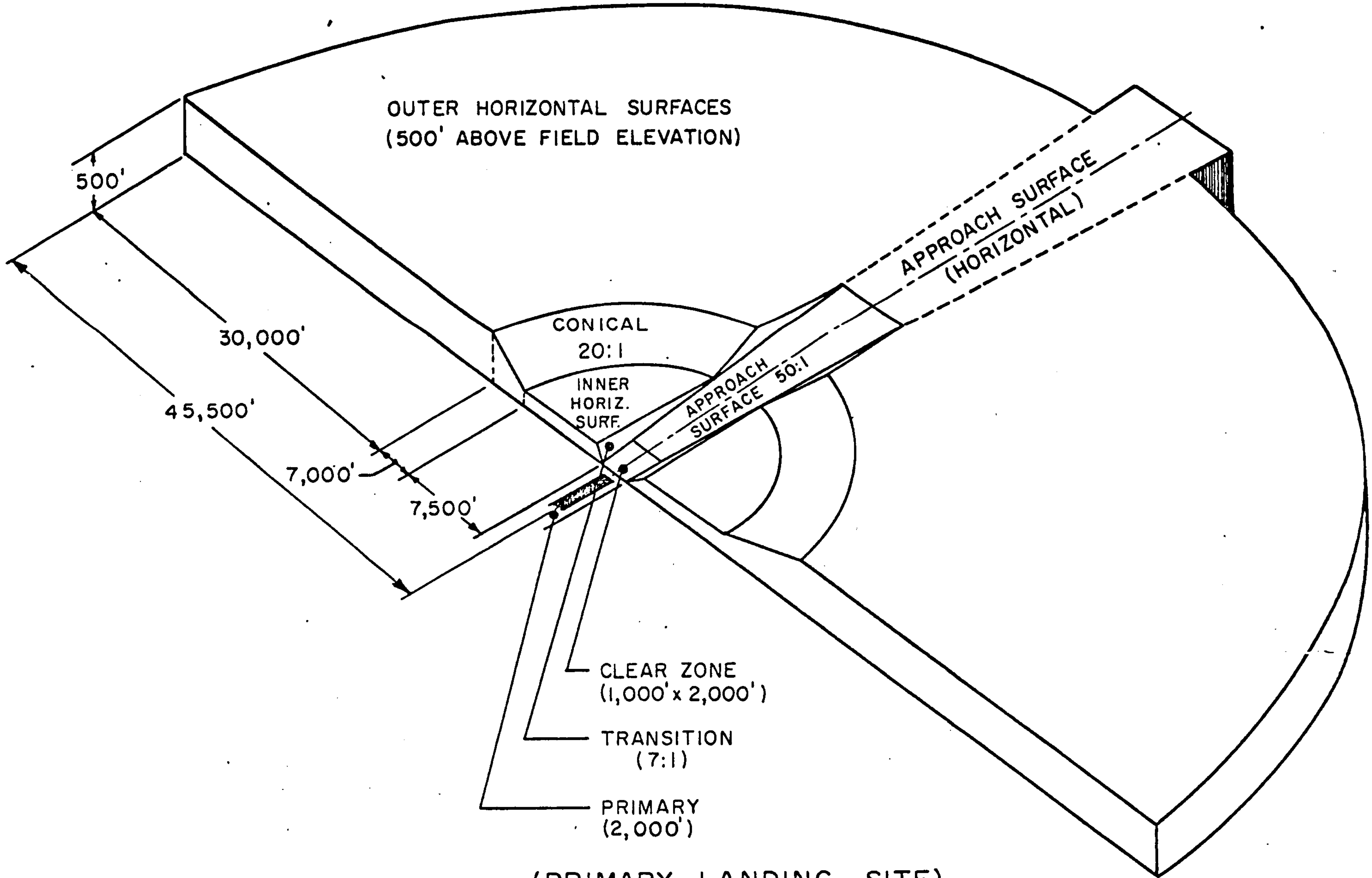


FIGURE 3.1

IMAGINARY SURFACES FOR SPACE SHUTTLE

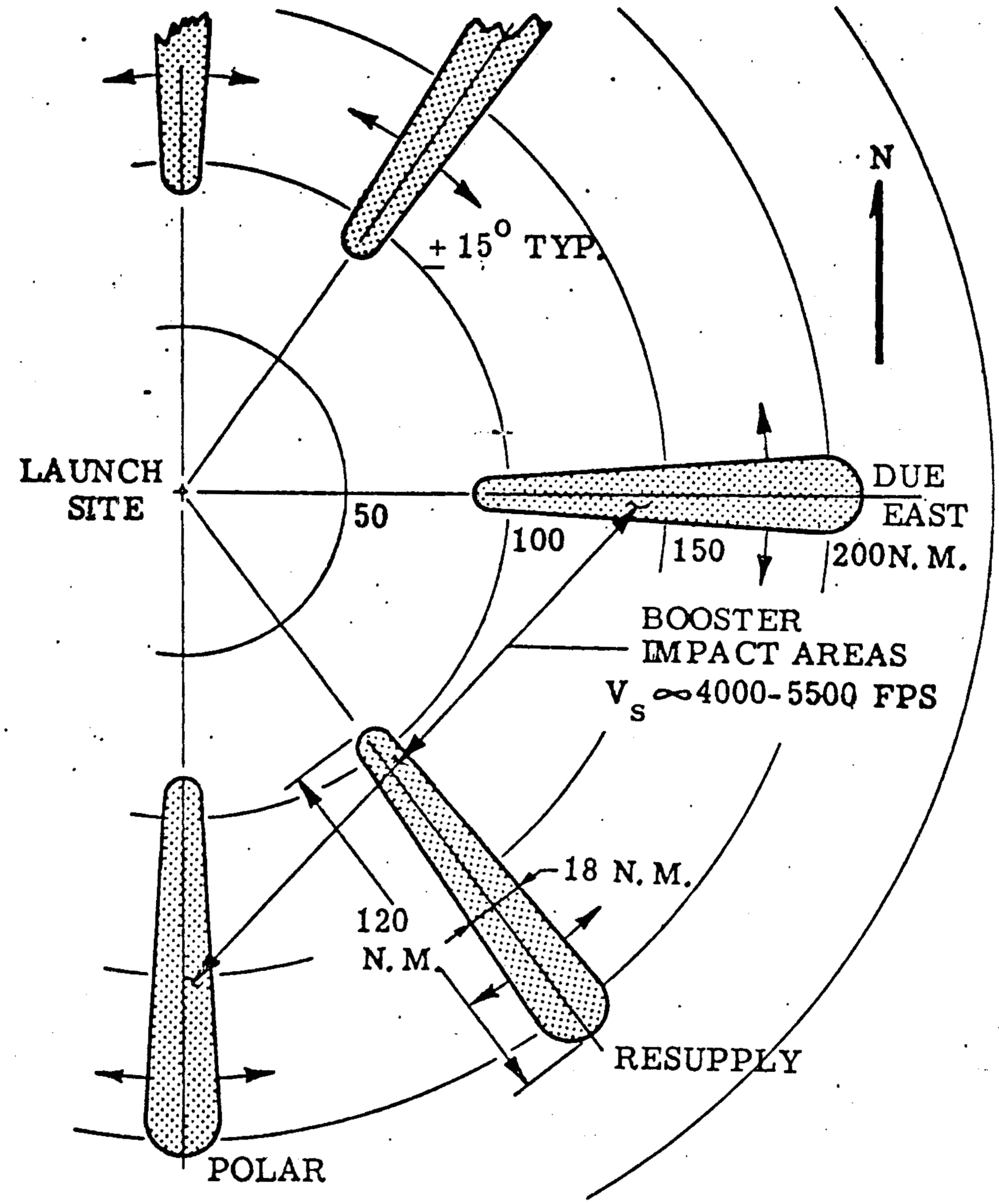


(PRIMARY LANDING SITE)

FIGURE 3.2

CANDIDATE SITE AREA BOOSTER IMPACT CRITERIA

LAUNCH SITE AND BOOSTER IMPACT



- PROVIDES, AS A MINIMUM, A LAUNCH AZIMUTH WITHIN 15° OF:
  - DUE EAST
  - POLAR (NORTH OR SOUTH)
  - RESUPPLY (NORTH OR SOUTH)

FIGURE 3.3

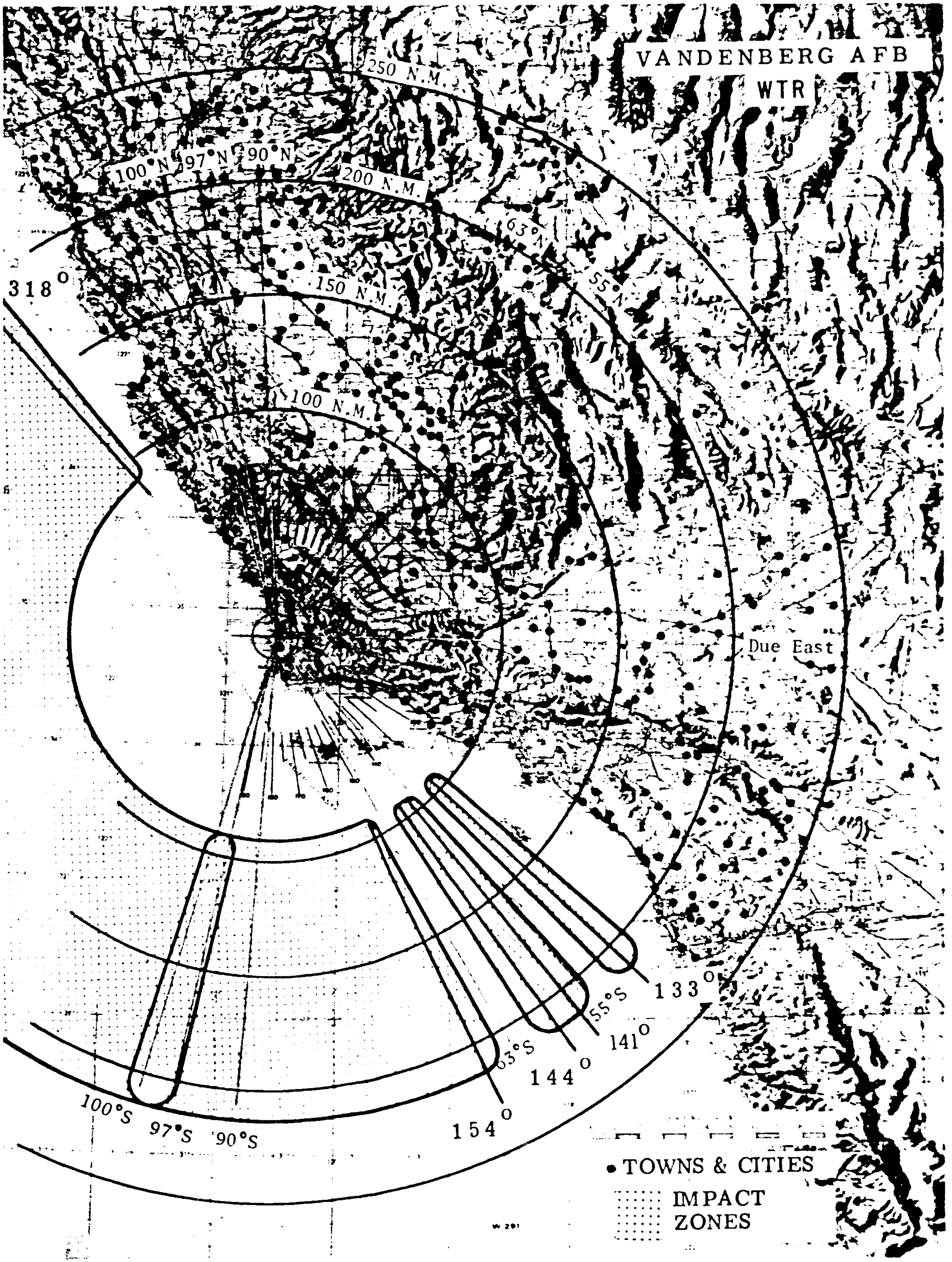
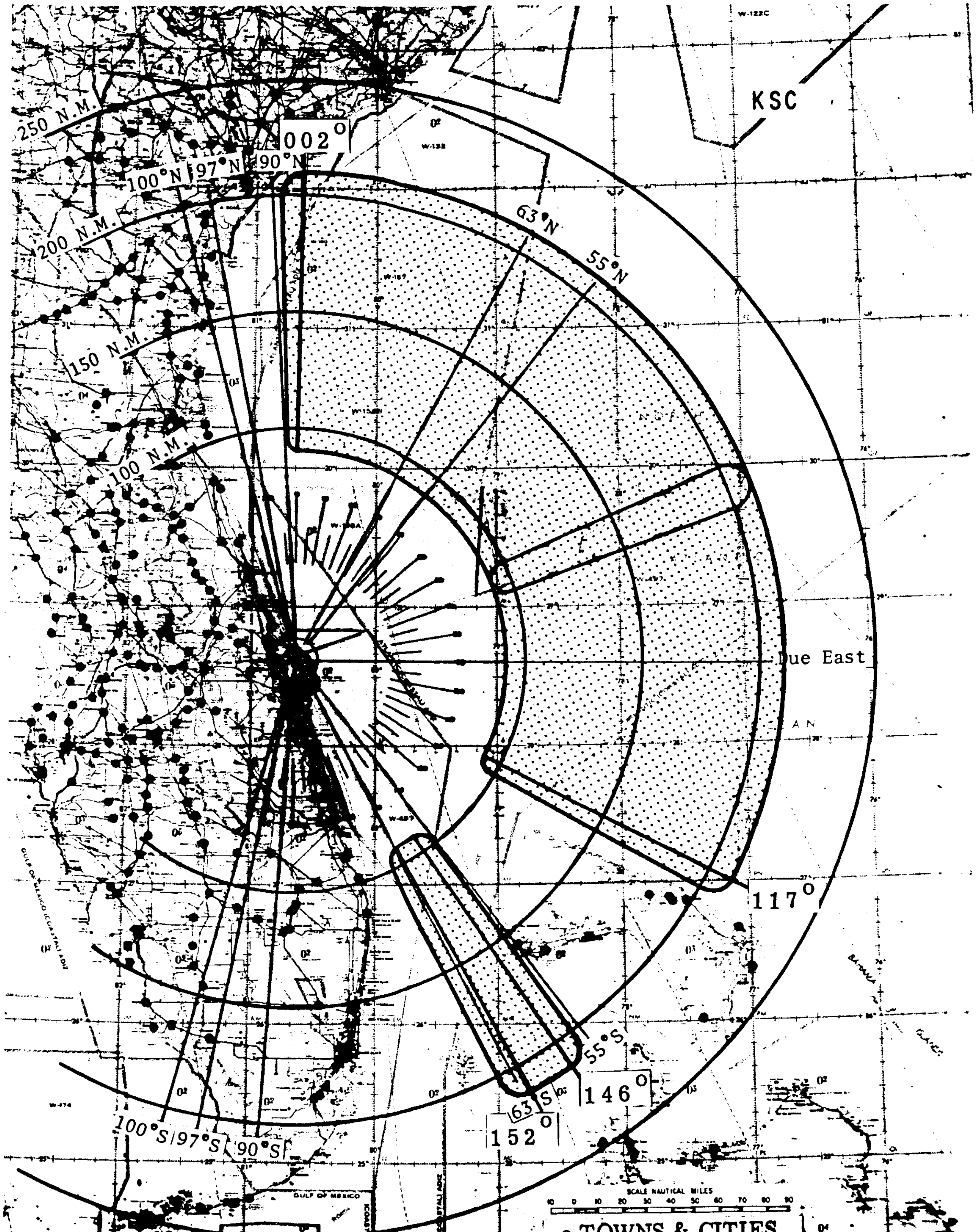
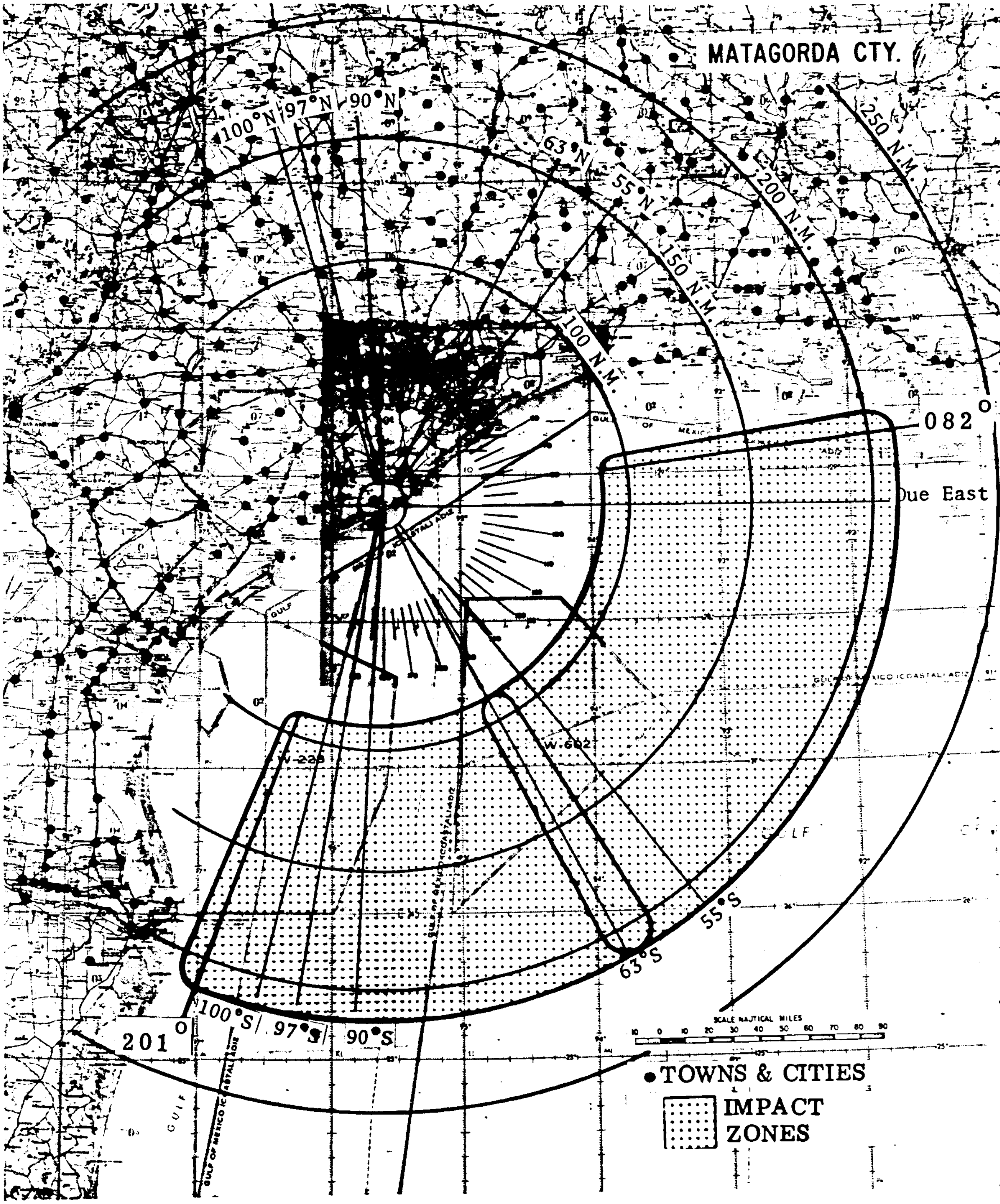

VANDENBERG AFB
WTR
250 N.M.
200 N.M.
150 N.M.
100 N.M.
100°N
97°N
90°N
63°N
55°N
318°
Due East
133°
55°S
141°
63°S
144°
154°
100°S
97°S
90°S
• TOWNS & CITIES
IMPACT
ZONES

FIGURE 3.4(a)



KSC
250 N.M.
200 N.M.
150 N.M.
100 N.M.
002°
100°N
97°N
90°N
63°N
55°N
Due East
117°
146°
152°
55°S
63°S
100°S
97°S
90°S
GULF OF MEXICO
SCALE NAUTICAL MILES
• TOWNS & CITIES
IMPACT ZONES

FIGURE 3.4(b)



MATAGORDA CTY.
250 N.M.
200 N.M.
150 N.M.
100 N.M.
100°N
97°N
90°N
63°N
55°N
082°
Due East
55°S
63°S
100°S
97°S
90°S
201°
SCALE NAUTICAL MILES
10 0 10 20 30 40 50 60 70 80 90
• TOWNS & CITIES
IMPACT ZONES

FIGURE 3.5

4. DETAILED EVALUATION

4.1 Cost Comparison of Alternative Site Options

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4.11 Summary of Results

The cost analysis shows that to construct and equip a new site for shuttle operations requires an investment of over $300M more than the cost of establishing the same capability at the two existing launch sites, KSC and Vandenberg. The analysis also shows that the cost savings in operation of the single site versus the dual site do not overcome this significant difference in initial investment costs and the added costs of phasing in the operations at a new site. The total cost for construction, equipment, and operation (through 1990) at a single site is more expensive by $228M (see figures 4.1 & 4.2). This difference, of course, does not recognize that benefits through lower annual operating costs will continue to accrue after 1990 for the single site alternative. On a present value basis -- using a discount rate of 10% -- the dual site cost advantage is $256M. However, considering the continuing savings after 1990, the cost advantage is reduced to $225M by extrapolating the $21M annual savings at a single site to infinity (see figure 4.3).

Based on DoD operational policies, the single site does include dedicated facilities for DoD use. However, the analysis includes other assumptions which result in a heavy bias in favor of a new site, e.g., the construction index at KSC and Vandenberg is 1.15 compared to 1.0 at the single site and no added contingency was included for the new single site although constructing a new facility at a virgin site would very likely involve a much higher risk than would apply to the dual existing sites.

The most compelling result, however, is that sensitivity analyses show that even if the investment costs at the new site were reduced by $316M to the level of the dual sites, the single site would not have an economic advantage on a present value basis. This is so because of the earlier

demand for funding at the single site. Further, if the annual operational cost advantage at the new site were doubled over the results derived in base-
27 line cost estimates and continued in perpetuity, the
28 cost difference in the two alternatives would be virtually zero.

Accordingly, the clear conclusion of this tradeoff study is that the single site does not have a favorable economic advantage over the existing two sites. This result occurs despite the fact that most of the economic factors and assumptions were biased in favor of the new site operations, e.g., the construction price index, activation costs, close-out costs at KSC, payload, range, and GSE costs all reflect benefit to new site.

4.12 The Analysis

Scope of Study

The economic analysis addressed total costs required to establish full operational capability at alternative sites. In the case of the transfer from present sites to a new site, only those costs incurred at the present site to complete the approved program and the relocation costs associated with transfer of existing functions were charged to the new site. Cost penalties were not assessed for monetary incentives to attract personnel to a remote site or inefficiencies due to regression in learning.

The general categories of costs identified for this study are:

(1) Facilities (figure 4.5): e.g., airfield, launch pads, vertical assembly buildings, etc.

(2) Launch site equipment (figure 4.6):

- (a) Vehicle GSE: Shuttle system checkout equipment at launch site.
- (b) Range instrumentation: Tracking, telemetry, range safety.
- (c) Support equipment: Shops, labs.

(3) Activation costs: Associated with installation of equipment in facilities, integration of equipment, and modifications required to bring total facility to operational readiness.

(4) Operations (figure 4.7): Costs associated with operating the launch and landing site at the required Shuttle launch rate, including payload processing and range support.

Facilities

The cost estimates for the facilities category were based on a functional analysis of the shuttle system, identifying the types and sizes of facilities required, modified by peculiarities at each specific site such as existing capability. The cost estimates were developed using conventional construction cost estimating methods, and included design engineering contingencies, and Government supervision, but not escalation. The construction price index used was biased in favor of a new single site. The results of the analysis indicate that the cost of construction at the existing dual sites (KSC/VAFB) is about $200M less than the cost of facilitizing a new single site. (Matagorda County was used in the analysis). The dual site assumes two pads at KSC for a 40 launch per year capability; one pad at VAFB for 20 per year; and three pads at the single site for 60 per year with one pad dedicated to DoD missions (see figure 4.4). The single site costs are estimated at $665M, including $90M for payload processing facilities, and $30M for range instrumentation and safety facilities. The dual site costs are estimated at $461M (see figure 4.5).

A detailed inventory of the construction items required at each site and the costs estimated for each item has been compiled and is attached as Appendix C to this section. A comparison of construction costs of the various sites reflects the wealth of facilities available at KSC and the difficulty of building at VAFB -- a single pad operation at VAFB is more than half the construction cost of a three pad operation at Matagorda, which includes over $70M for purchase of land and site preparation, in addition to the range and payload processing costs cited above.

The payload processing facilities ($90M) and range instrumentation and safety facilities ($30M) are significant costs associated with the new site. These values were estimated following an intensive analysis of requirements, launch rate, and historical costs. The minimum requirements approach was used in developing these values and they represent the minimum level necessary to establish the shuttle capability as presently understood.

<u>Launch Site Equipment</u>

The launch site equipment estimated at each location included vehicle GSE requirements, payload processing, and range instrumentation. The vehicle GSE was established based on an inventory, by line item, of major equipments as priced by one of the major shuttle vehicle prime contractors during the Phase B costing. The inventory was analyzed for quantity impact based on the rate at each launch site. The cost at the single launch site was $56M compared with $84M at the dual sites (see figure 4.6). In the case of range equipment, each site was configured in terms of minimum range instrumentation necessary to satisfy mission and safety requirements. These requirements were reviewed with DoD, MSC, KSC, and OTDA. The results of this assessment indicated that a new range at the single site would cost about $85M and that the present range at VAFB required about $21M of augmentation for a dual USB capability. In developing the payload processing requirements for the shuttle operational capability, the generic paylods and expendable stages in the NASA mission model were reviewed. The payload processing functions indicated by the classes of payload were defined and the equipments necessary to perform the function were identified, together with the capability to accommodate the launch rates in the mission model. The historical costs of equipments required to prepare the payloads were analyzed and an estimate for establishing this capability at the various sites was prepared. A critical assumption in the costs of the payload processing equipment was that most of this equipment (70%) available at an existing site, could be moved to a new site. On this basis, a cost of $28M for payload equipment was included for the new site.

Site Activation

Site activation was estimated using a factor based on recent experience applied to the total construction and equipment cost. The factor applied was 27% at all sites. This factor is less than the 30% experienced on major Apollo sites, i.e., KSC and MTF and more than the 12-15% experienced on some large DoD activities. e.g., Titan III at ETR.

Operations

The operations estimates for the launch and landing sites include: vehicle and payload checkout and launch crews; technical shops and lab support; dedicated range support; administration and housekeeping support personnel; and supplies, propellants, spares, and other logistics (see figure 4.7). The launch and checkout crews were estimated based on historical crew sizing factors keyed to units in flow. Empirical data indicates that for a launch rate of 20 per year, one unit is in flow; 40 per year indicates two units in flow; and 60 per year indicates three in flow. Our history reflects that the crew size for the second unit in flow is about 70% of the first and 50% of the first crew for the third crew. Total manpower for each case is shown in figures 4.8, 4.9, and 4.10.

Program and technical support crews and base support manpower were developed from man-loading requirements for each group based on engineering manning estimates for functions required to be supported for the number of vehicles in flow for vehicle sensitive functions and for facilities and maintenance requirements for others. The level of civil service manpower was kept at 2,400 for each case.

Estimates for shuttle logistics support are based on quantities keyed to launch rate for propellants, spares, and other vehicle sensitive supply requirements. Estimates for general support for both R&D and R&PM are based on current spending rates, adjusted to estimated total manpower to be supported and the number of sites in operation.

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The support required for the phasedown of current KSC programs includes unmanned launch operations through 1981 and current manned program schedules through the docking mission in 1975. ULO support requirements have been adjusted, as appropriate, in the single site case to reflect the phaseout of KSC.

Other Considerations

The impact of locating a launch and landing operation of the dimensions of the shuttle on an undeveloped geographical area could require significant additional Federal funds to provide or improve community services such as water, sewage, schools, highways, hospitals, fire and police, post office, etc. Based on the direct manpower at the new single site, it can be estimated that the total population of the local community would approximate 60,000. The extent of Federal participation in assisting the community improvement obviously determines the funding requirements. The estimates do not include consideration of these potential additional requirements. A review of the Government/community growth experience at KSC/ETR indicates a community size of about 250,000 and direct Federal assistance of about $125M.

4.2 Site Evaluations

4.21 Kennedy Space Center/Vandenberg Air Force Base

Performance Capability

This pair of sites has jointly satisfied most of the national launch requirements for over 10 years and has the capability to meet all foreseeable requirements. These sites complement each other. KSC provides clear launch azimuths in the easterly direction for low inclination orbits. These orbits will carry the bulk of Shuttle program missions including the early development flights. The easterly direction provides the greatest margin for assuring orbit insertion. The polar flights which would require dog-leg maneuvers from KSC can be easily accommodated at VAFB. Most importantly, VAFB can provide the westerly launches required in certain Air Force missions. Thus these two sites meet the known requirements of the national program and afford opportunity for full utilization of Shuttle capabilities. Booster impact and recovery zones are available. The ability to launch toward open ocean areas provides space for emergency jettison of H-O tanks and gives freedom from land overflight early in the ascent trajectory. The existing sites fit conveniently into overall logistics planning. KSC facilities could be used for H-O tank transport and the dock area could be modified to accept the towed recovered booster. Recovery at Vandenberg would require construction of necessary dock facilities; these costs were included in the economic analysis.

Environmental Impact

In over 10 years of operating experience, the environmental impact of launch programs at KSC and VAFB have been wholly acceptable. As the Shuttle program will be within the limits of NASA and Air Force experience with Saturn and Titan vehicles, there is confidence that the environmental impact of the Shuttle will also be acceptable. The Board presumes that similar operating procedures will be developed so that the experience will be directly applicable to the Shuttle program.

Launch azimuths are available which will place ascent
sonic booms over water areas where their effects will
33) be acceptable (see Section 5.12). Adequate buffer
34) zones are available so that engine noise levels during
the launch will not exceed acceptable levels in the
surrounding communities. The environmental implications of engine exhausts are treated in Section 5.21; successful Titan experience applies directly to KSC and VAFB giving greater confidence of acceptable environmental impact of the program. Current launch operations at both KSC and VAFB use cooling water to protect the flame deflector. This water is contained and allowed to cool before release so the risk of thermal pollution is slight. Finally, in the experience of the launch program, no adverse effect on wildlife has been observed at KSC or VAFB.

The community impact at KSC would be favorable. Peak space program employment at KSC was about 25,000; this figure is now about 15,000. Thus the community has the capacity to accept this program. Since the development program would be performed at KSC, the build-up at VAFB could be gradual and phased to be acceptable. Of the two options, utilization of the existing sites would provide the lesser disruption.

Programmatic Factors

The cost studies show utilization of the existing sites to be the lower cost mode of operation. Range equipment, payload processing, and data handling facilities and experienced personnel are resident at KSC -- and to a lesser extent at VAFB. These lead to a much lower initial cost for KSC/VAFB which outweighs the ultimate savings in operations cost at a single new site.

Operating experience at KSC and VAFB and freedom from the necessity for land gives much greater assurance of meeting funding limitations and scheduling requirements.

4.22 Matagorda County, Texas

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Mission Capability

A range of sites in the county were identified for possible site location including the Air Force facility on Matagorda Island. Of this range, a mid-county site seemed most acceptable but on due-east launches could create a focal zone on land. This could be avoided through recourse to launch vehicle maneuvers which would, however, degrade vehicle performance. The payload margin which exists for due-east launches may be adequate to cover these maneuvers.

Booster impact and recovery zones are available. However, the orbiter ground track for due-east and sun-synchronous launch azimuths passes very close to land. Abort maneuvers could place the ground track or instantaneous impact points over land. Thus there is less room for flexibility in abort planning and potentially less area for emergency jettison of H-O tanks in Gulf-coast launches. The Gulf-coast site could fit conveniently into logistic planning. It is accessible by barge and rail. It is close to the Manned Spacecraft Center for management purposes. And due-east launches have impact zones not too distant from the Michoud Facility which could be used for refurbishment of the recovered boosters.

Environmental Factors

Environmental factors for this site have not been fully evaluated. Based on experience elsewhere, facilities would be developed and operated to assure acceptable environmental impact (e.g., containment of cooling waters, weather survey prior to launch). Sonic boom limitations were discussed above. Site design and land acquisition would have to provide buffer zones to assure acceptable noise levels in surrounding communities.

However, the need to acquire land is a potential source of adverse community impact and disruption. This is also a potential source of delay in conducting the program because of the possibility of litigation. Though land was

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acquired for KSC and MTF, there is considerably more environmental concern at this time. In addition, if the land is occupied there is now specific legislation regarding relocation of the inhabitants prior to acquisition. Finally, selection of Matagorda could potentially disrupt three communities, KSC, VAFB, and Matagorda County.

Programmatic Factors

The cost studies show the large initial investment in the new site to outweigh the eventual savings in operating costs. If anything, the risk of delays tend to increase the initial costs at a new site. In view of the absences of clear cost or mission performance advantages, the Board questions the need to pursue further the evaluation of this or any other new site.

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National Aeronautics and Space Administration

SUMMARY OF TOTAL COSTS THROUGH 1990
(Millions of 1971 $)

	Single Site	Dual Site	Δ
Facilities	665.0	461.0	+204.0
Equipment	198.7	138.8	+59.9
Site Activation	173.0	121.0	+52.0
Operations	4,328.1	4,415.7	-87.6
Total	5,364.8	5,136.5	+228.3

FIGURE 4.1

SPACE SHUTTLE PROGRAM – LAUNCH & LANDING SITE STUDY – SINGLE/DUAL SITE TOTAL COSTS

FY	73	74	75	76	77	78	79	80	81	82	83	84	85 - 90
MISSION MODEL						2	10	20	26	35	50	54	60-60-60-60-60-60
SINGLE SITE		322	640	567	446	363	324	230	228	224	242	248	254
DUAL SITE		266	298	298	463	450	405	274	248	243	260	267	275
		+56	+342	+269	-17	-87	-81	-44	-20	-19	-18	-19	-21

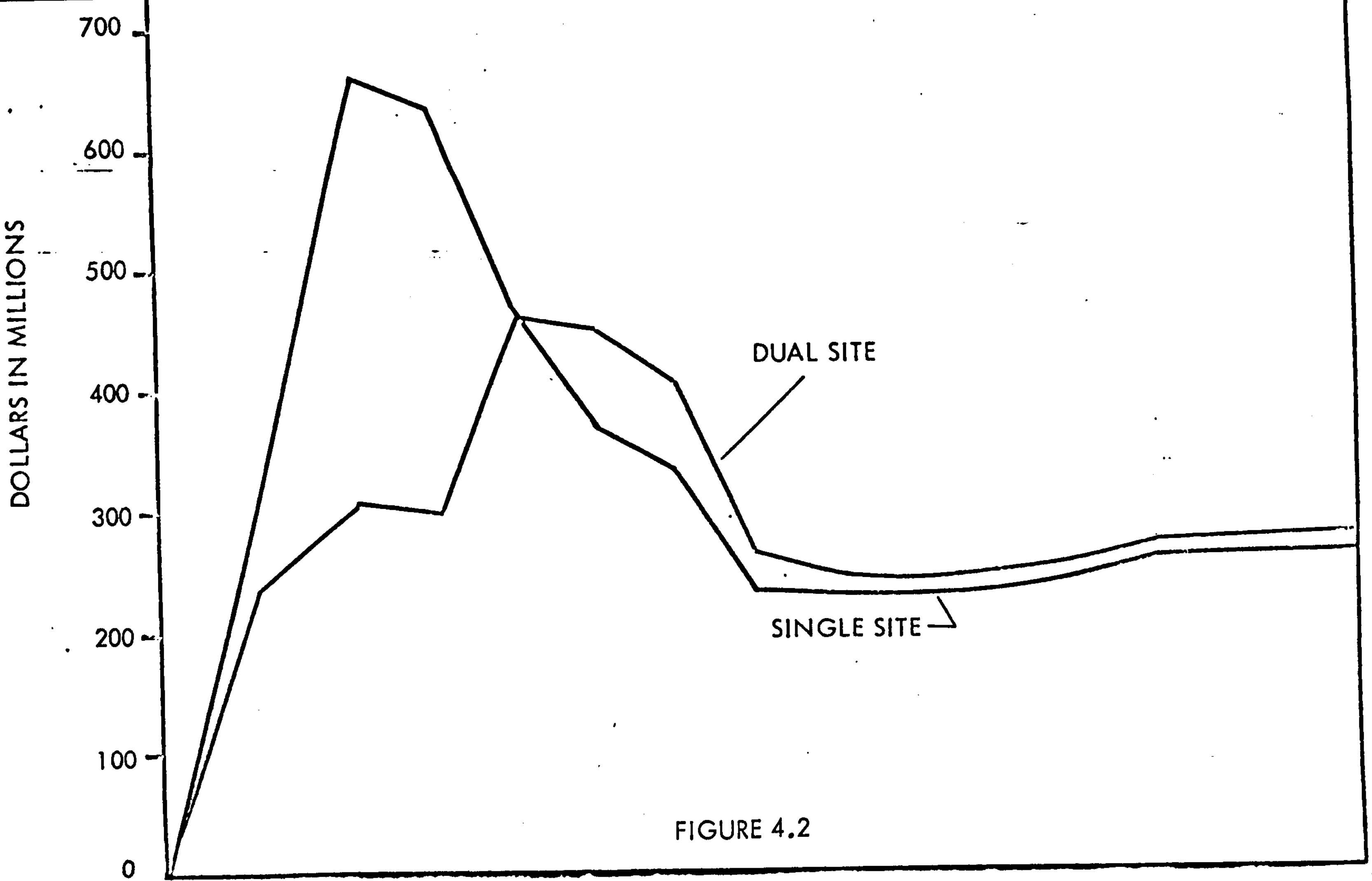

FIGURE 4.2

National Aeronautics and Space Administration

PRESENT VALUE COST COMPARISONS

	Single Site	Dual Site	Δ
1973-1990:			
Nominal	5,366	5,138	+228
@ 10%	2,134	1,878	+256
After 1990:	(254/Year)	(275/Year)	(-21)
@ 10%	378	409	-31
Total @ 10%	2,742	2,536	+225

FIGURE 4.3

National Aeronautics and Space Administration

SUMMARY OF REQUIREMENTS

	Single Site	Dual Site KSC	Dual Site WTR	Dual Site Total	Δ
Fleet Size (Orbiters)	5	3	2	5	---
Launches Per Year	60	40	20	60	---
Pads	3	2	1	3	---
Mobile Launchers	3	2	2	4	-1
Vertical Assembly, High Bays	3	2	1	3	---
Firing Rooms	3	2	1	3	---
Maintenance and Checkout: Orbiter					
Orbiter Bay	3	2	1	3	---
TPS Bay	1	1	1	2	-1
H/O Tanks	6	4	2	6	---
Mobile Test Stand Flight Readiness	1	1	1	2	-1

FIGURE 4.4

National Aeronautics and Space Administration

LAUNCH AND LANDING FACILITIES
(Millions of 1971 $)

	Single Site	Dual Site ETR	Dual Site WTR	Dual Site Total	Δ
Planning and Design	52.0	8.0	26.0	34.0	+18.0
Land Acquisition/Site Preparation	72.0	---	3.4	3.4	+68.6
Launch Support	228.0	68.3	163.9	232.2	-4.2
Vehicle Landing	25.0	26.9	19.2	46.1	-21.1
Maintenance	25.7	12.0	13.6	25.6	+.1
Logistics	44.7	.7	46.9	47.6	-2.9
Administration	20.8	.3	4.2	4.5	+16.3
Utilities	46.8	4.8	29.9	34.7	+12.1
Payload Facilities	90.0	---	21.9	21.9	+68.1
Range Safety/Tracking	30.0	---	11.0	11.0	+19.0
Air Force Peculiar	30.0	---	---	---	+30.0
Total	665.0	121.0	340.0	461.0	+204.0

FIGURE 4.5

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National Aeronautics and Space Administration

LAUNCH SITE EQUIPMENT SUMMARY
(Millions of 1971 $)

		Dual Site			
	Single Site	KSC	WTR	Total	Δ
Support Equipment	57.7	14.1	19.8	33.9	+23.8
Range Equipment	85.0	---	20.9	20.9	+64.1
Vehicle GSE	56.0	47.2	36.8	84.0	-28.0
Total	198.7	61.3	77.5	138.8	+59.9

FIGURE 4.6

National Aeronautics and Space Administration

COMPARISON OF OPERATIONS COSTS
(Millions of 1971 $)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985-1990*
Single Site												
Shuttle Ops. & Logistics	5.8	30.4	124.1	146.5	175.5	181.4	105.7	110.6	122.6	140.5	146.8	152.4
Range Operations	---	---	3.7	7.5	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2
ULO Operations	24.7	24.7	25.5	25.5	25.5	25.5	19.9	13.6	---	---	---	---
KSC Other Operations	96.3	92.7	8.7	2.5	---	---	---	---	---	---	---	---
Civil Service	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1
Other Support	39.1	59.1	52.1	44.1	41.1	40.1	39.1	39.1	37.0	37.0	37.0	37.0
Total	217.0	258.0	265.6	277.2	306.4	311.3	229.0	227.6	223.9	241.8	248.1	253.7
Dual Site												
Shuttle Ops. & Logistics	---	26.5	115.7	146.1	174.5	189.2	119.2	128.8	140.6	157.8	161.6	167.2
Range Operations	---	---	1.9	3.9	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
ULO Operations	24.7	24.7	19.7	19.7	19.7	19.7	15.4	11.0	---	---	---	---
KSC Other Operations	96.3	92.7	---	---	---	---	---	---	---	---	---	---
Civil Service	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1
Other Support	37.1	35.1	30.1	31.1	39.4	43.7	42.5	42.9	42.6	42.6	46.5	47.9
Total	209.2	230.1	218.5	251.9	293.5	312.5	237.0	242.6	243.1	260.3	267.0	275.0
Δ	+ 7.8	+27.9	+47.1	+25.3	+12.9	-1.2	-8.0	-15.0	-19.2	-18.5	-18.9	-21.3

*Cost per year, 1975-1990.

FIGURE 4.7

SPACE SHUTTLE PROGRAM
LAUNCH & LANDING SITE SUTDY
KSC/WTR MANPOWER PHASING PLAN

FY	73	74	75	76	77	78	79	80	81	82	83	84	85 - 90
MISSION MODEL						2	10	20	26	35	50	54	60-60-60-60-60-60
MANPOWER KSC		8180	9790	6735	7935	8830	9980	9520	9520	9240	9515	9515	9515
MANPOWER WTR		130	130	180	180	480	830	900	865	880	880	880	880
TOTAL		8310	9920	6915	8115	9310	10810	10420	10385	10120	10395	10395	10395

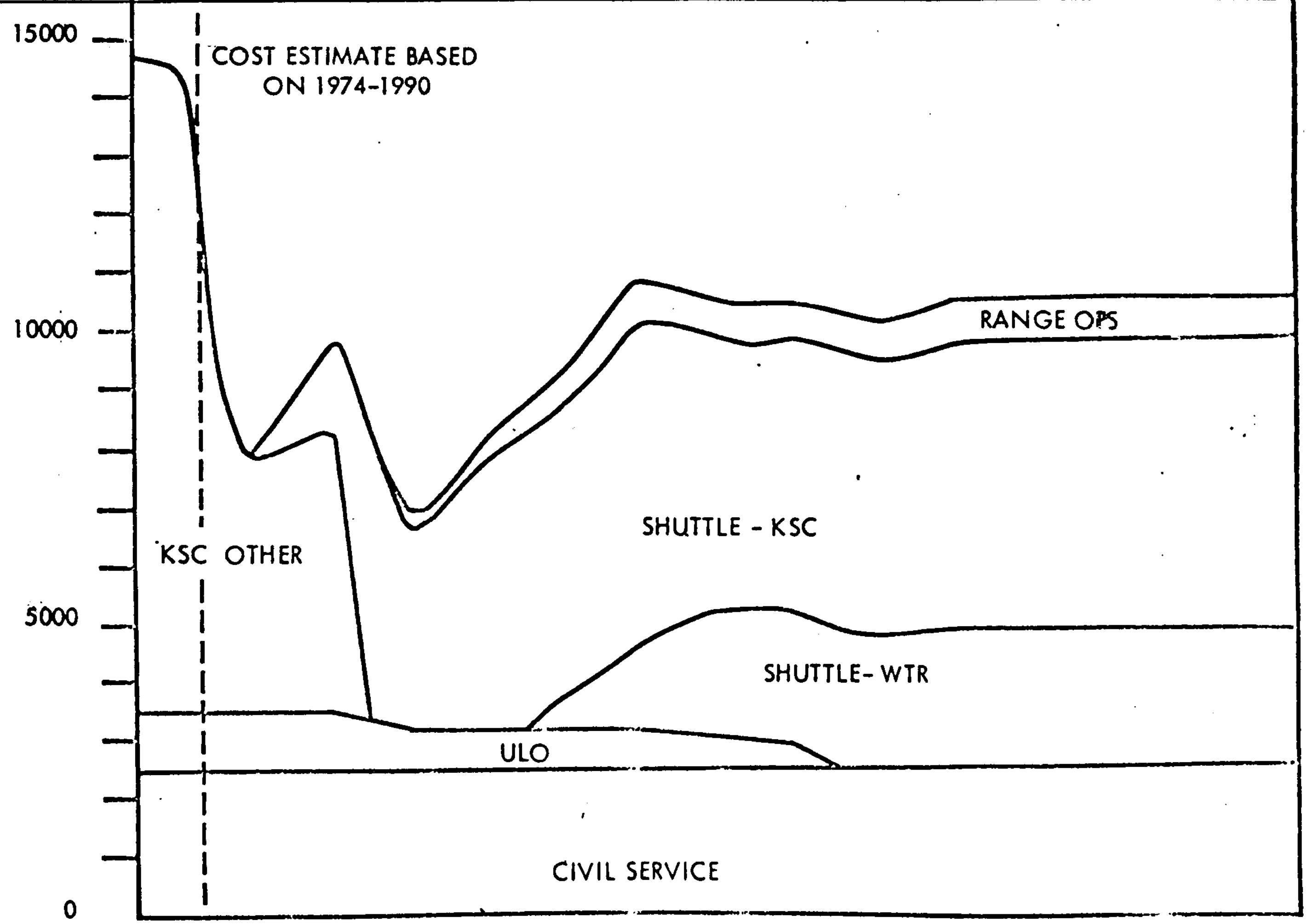

FIGURE 4.8

SPACE SHUTTLE PROGRAM
LAUNCH & LANDING SITE STUDY
APRIL 6,1972
SINGLE SITE MANPOWER PHASING PLAN

FY	73	74	75	76	77	78	79	80	81	82	83	84	85-90
MISSION MODEL						2	10	20	26	35	50	54	60-60-60-60-60-60
MANPOWER		8910	10420	8365	9175	10600	10725	9635	9385	9210	9510	9635	9635

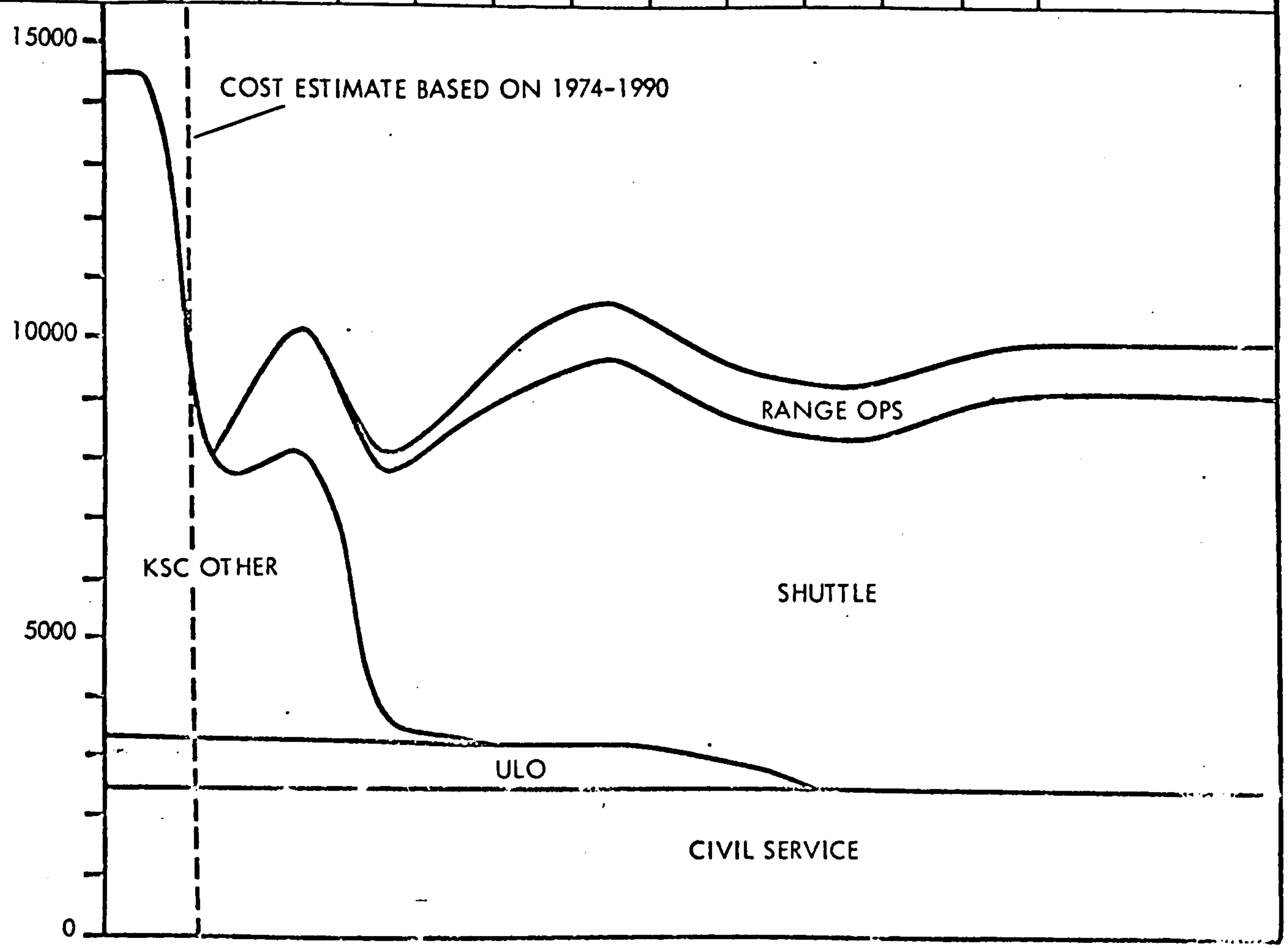

FIGURE 4.9

SPACE SHUTTLE PROGRAM

LAUNCH & LANDING SITE STUDY

MANPOWER PHASING PLAN

FY	73	74	75	76	77	78	79	80	81	82	83	84	85 - 90
MISSION MODEL						2	10	20	26	35	50	54	60 PER YEAR
SINGLE SITE		8910	10420	8365	9175	10600	10725	9635	9385	9210	9510	9635	9635
DUAL SITE		8310	9920	6915	8115	9310	10810	10420	10385	10120	10395	10395	10395
△		+600	+500	+1450	+1060	+1290	-85	-785	-1000	-910	-885	-760	760

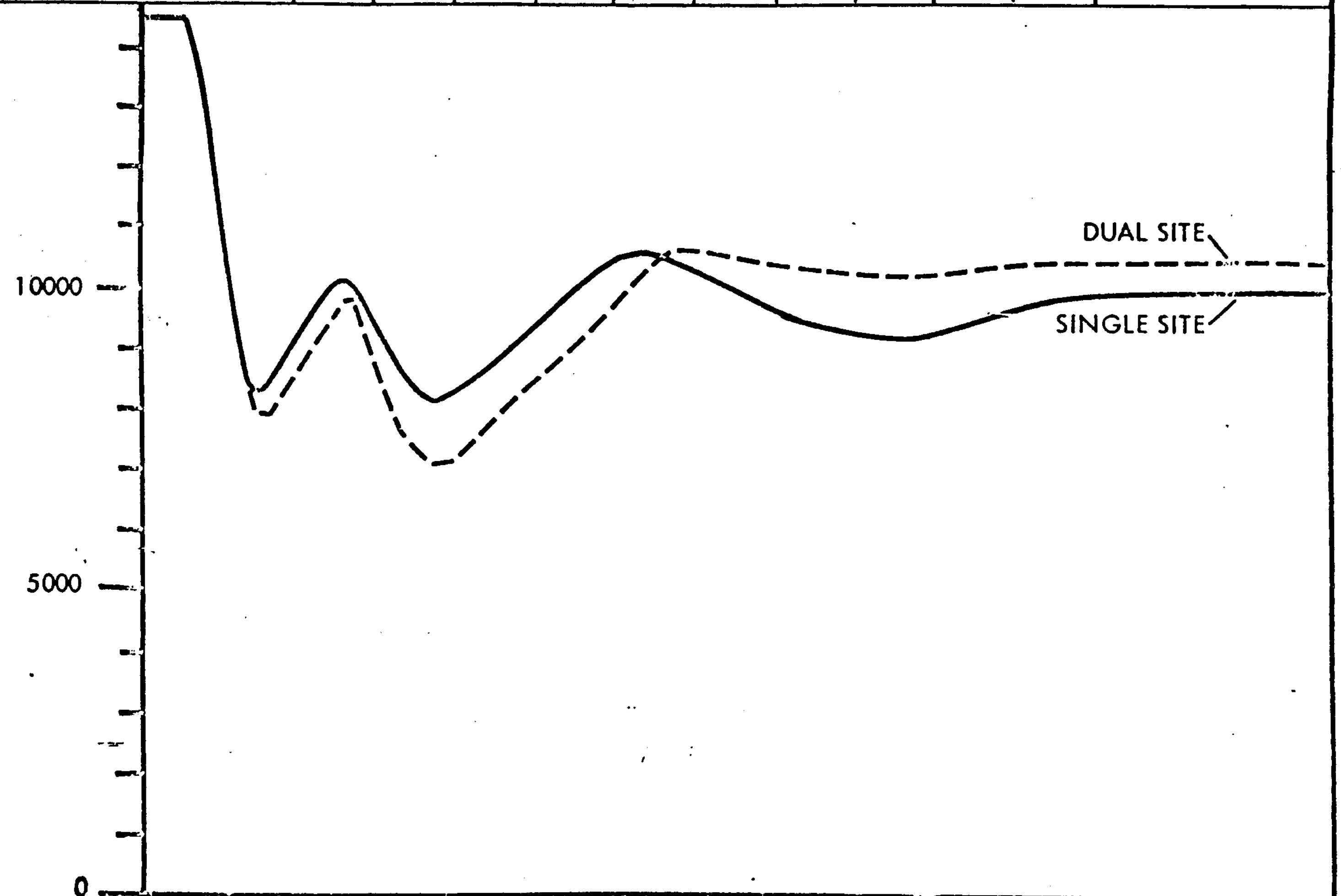

FIGURE 4.10

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5. ENVIRONMENTAL CONSIDERATIONS

5.1 Noise

5.11 The Sonic Boom

As any body flies through the air, the air must part to make way for that body and then close itself once the body has passed. In subsonic flight, pressure signals (precursor waves which travel at the speed of sound) move ahead of the body to forewarn of its approach. So the parting of the air and the passage of the body is a smooth process. In supersonic flight, precursor waves cannot precede the body; the parting process is abrupt. A bow shock wave parts the air which generally expands as it passes around the body and then a trailing shock wave recompresses the air as it closes behind the body. This general pattern of bow shock wave, expansion region, and recompression shock is idealized as the N-wave signature commonly associated with the sonic boom. (See figure 5.1 for further nomenclature.)

The abruptness of the pressure changes are responsible for much of the concern about the sonic boom. They give it the startling audibility and dynamic characteristics of an explosion, and even at great distances from the vehicle where, according to the results of many studies, the pressure levels produced are physically harmless, some public complaints are received. These facts are of concern in Shuttle operations because segments of the trajectories followed during ascent and descent involve supersonic flight within the atmosphere.

The characteristics of the shock pattern at its source are influenced by flight path characteristics -- e.g., altitude, speed, and accelerations either along or transverse to the flight path -- and body characteristics such as bluntness, weight, and volume. The pressure signature that reaches the ground is subject to the additional factors of air turbulence and temperature variations of the atmosphere traversed by the pressure wave.

Extensive knowledge of these factors developed by past studies of conventional supersonic aircraft provided much of the basic information required for prediction of the sonic boom pressure patterns (i.e., footprints) of the Shuttle. It was necessary, however, to extend this basic knowledge by additional studies and experiments so that it would apply to the Shuttle shape and the extremely high speeds and altitudes at which it operates.

An authorative summation[1] of the aircraft results has been recently provided by the International Civil Aviation Organization (ICAO). In review of the effects of sonic boom, the ICAO Panel concluded:

1. The probability of immediate direct injury to persons or animals exposed to sonic boom is essentially zero.

2. The percentage of persons queried who rated a sonic boom as annoying increased with increasing overpressures. For overpressures less than one-half pound per square foot (psf), no one rated the boom as annoying, whereas about 10 percent considered one psf annoying, and nearly all considered 3 psf annoying. Annoyance factors are, however, greatly influenced by the frequency of occurrance. In the test subject evaluation of noise levels quoted by ICAO, the subjects were asked to base their response on a projected rate of occurrence of 10-15 booms per day.

3. Primary (loadbearing) structures meeting acceptable construction standards or in good repair showed no damage up to overpressures of 20 psf. Nonprimary structures such as plaster, windows and bric-a-brac sustained some damage at overpressures of from one to three psf.

4. Ground motions from sonic booms were found to be of the same order of magnitude as those caused by normal occurrences such as footsteps, running, vehicular traffic, etc.

Three phases of the Shuttle mission create sonic boom disturbances - ascent, booster entry and orbiter entry. Each mission phase is discussed separately.

Ascent

The ascent leg will create the largest magnitude sonic booms of the mission. Two effects cause the sonic boom levels to be more severe than for the entry phases. The first is a focusing condition created by the combination of the longitudinal acceleration and pitch over maneuvers necessary for the vehicle to achieve orbit. These factors result in a parabolic-shaped focal area which is located approximately 33 n.mi. from the launch site along the ground track and extends in a curved arc (curving away from the site) for about 40 n.mi. to either side of the track (i.e., out to lateral cutoff). Lateral cutoff occurs when the local gradient in the speed of sound causes the ray path to turn to a horizontal (parallel to the ground) orientation. This focus zone occurs at the first intersection of the sonic boom disturbance with the ground level. No sonic boom disturbance will occur between the launch site and the focal zone. Overpressure levels within the focal region cannot be predicted by theory; however, flight test data for aircraft indicate that the pressures may be expected to be two to five times nominal values with focus factors of up to nine having been measured for some very severe maneuvers.

The second effect increasing the severity of the sonic boom for ascent is the rocket plume. The plume increases the effective size of the vehicle and preliminary tests have indicated that the nominal overpressures may be at least doubled due to plume effects. Predictions of the overpressures along the ground track near the focal region including plume effects show that nominal levels of 6 psf or higher may be expected. Thus, levels approaching 30 psf cannot be completely ruled out in the focal zone.

The intense overpressures in the focal zone will be limited to a very narrow region along the track on the order of 300 meters in depth which would diminish in depth moving away from the track toward lateral cutoff. Nominal overpressures outside the focal zone decrease in level with increasing distance from the groundtrack, and from flight data we know that the focus factors tend to stay constant or decrease with increased distance from the groundtrack. These conditions lead to the conclusion that overpressures of 10 psf are possible near the lateral cutoff of the focus zone.

At a distance of 45 n.mi. from the launch site, the sonic boom overpressure level will have decreased to less than one psf.

The existence of the focal zone must be recognized in Agency planning. An analysis will be conducted to determine if trajectory tailoring can eliminate this condition without seriously restricting payload. This study must, however, evaluate a great many parameters and cannot be realistically undertaken until a more precise knowledge of staging velocity and the nominal trajectory is available. Also, it should be recognized that the estimates of overpressure for the ascent phase are based on experimental and flight data obtained on a series burn launch system. A study of the effects of parallel burn will be conducted in the first quarter of FY-73 (including ground testing by the Ames Research Center) which will provide higher confidence level predictions for Shuttle operations.

Based on the current understanding of the ascent sonic boom characteristics and the knowledge of the effects of sonic boom disturbances obtained through the aircraft programs, the Board feels that the severe overpressures associated with the focal zone must be prevented from occurring in any inhabited area. The area subjected to the focal zone (less than 10 square n.mi.) and the location for a still atmosphere may be predicted accurately. Winds, however, can cause significant shifts in the location of the focal zone so that a much broader area must be cleared than that which would be effected during a single launch. Using the detailed wind model developed for KSC and calculating the dispersions that would be experienced for a 95 percentile wind from various directions the focal zone may shift as much as 5 n.mi.uprange (toward the site) and 3 n.mi.downrange.

Finally, focus booms occur during the Apollo launches, but are unnoticed since they occur over a very small area at sea.

Booster Entry

After stage separation, the orbiter stage continues to accelerate to orbit while the booster stages reenter the atmosphere. Based on current estimates of staging velocity, the spent solid rocket motors are expected

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to splash down at a distance no greater than about 220 n.mi. downrange of the launch site. After staging, the sonic boom disturbance from the spent cases is initially very low ($\sim$.01 psf) with the level increasing rapidly after the cases past apogee and begin the ballistic entry. Predictions based on representative sonic boom signatures shown that the maximum overpressure during booster entry (near splashdown) will be between 2-3 psf, similar to that experienced with the Nation's current stable of expendable launch vehicles.

Superimposed on the area covered by the booster entry sonic boom disturbance will be the overpressure created by the orbiter as it continues to orbit. This footprint has the opposite characteristics of decreasing overpressure with increasing distance from the launch site. Due to differences in velocity and altitude, the two disturbances would not be expected at a given location on the ground simultaneously. In the area of greater than 55 n. mi. downrange but less than 122 n. mi. (prior to booster entry), the overpressure level will be less than 0.25 psf across the footprint.

Orbiter Entry

Based on extensive analytical work throughout the Agency and on an exhaustive experimental program conducted by the Ames Research Center, the sonic boom characteristics of the orbiter vehicle, which will have significant segments of land overflight, are available to a fine level of detail and high level of accuracy. Nominal overpressures during orbiter entry will not exceed one-half psf until the vehicle is within 350 n.mi. of the launch site. Overpressures of one psf are exceeded at about 100 n. mi. from the launch site and the peak overpressure for an open loop guidance system would be less than 1.5 psf. Closed loop guidance schemes which will require some maneuvering in the terminal portion of the entry for error correction can increase the overpressures, particularly in localized areas. A preliminary analysis of realistic, closed-loop entries indicated, however, that limits on the guidance system should permit control so that the nominal maximum overpressure for any orbiter entry will not exceed 2.0 psf. (More detailed information will be available by mid 1972.)

The sonic boom characteristics associated with orbiter entry are, therefore, at worst in the range of nuisance or annoyance. Analysis of the extensive aircraft experience has not provided any correlation for overpressures of this magnitude and expected physical damage. The annoyance factor associated with these low levels of overpressure is also very questionable due to the infrequency of occurrences. As mentioned earlier, the ICAO conclusions were based on an estimated frequency of 10-15 times per day. Except for the immediate area of the launch site (within 40 n.mi.), any given area would not be expected to experience booms exceeding one psf more than a few times per year due to the varying approach angle to the launch site caused by varying inclination and return opportunity.

In summary, the Site Evaluation Board has considered the capability to place the sonic boom footprint so that the impact on existing communities and the potential restriction to flight operations are minimized as a screening criteria in site assessment. Trajectory shaping studies coordinated with systems design and flight operations activities aimed at alleviating the sonic boom overpressures and/or controlling the placement of the footprint in acceptable areas will continue. In light of our current understanding of the sonic boom characteristics, the severe focal boom region occurring early during ascent must be given special consideration; for the remainder of the mission, overpressures are down in the gray area of questionable nuisance or annoyance.

5.12 Sonic Boom over Ocean Areas

Available evidence shows it to be highly unlikely that adverse effects will result from Shuttle-generated sonic booms over the ocean. According to the ICAO report (1), "Experience from Concorde test flights over water and many years of military flying over the sea, in particular near land where many ships and small boats are found, has not yielded any evidence of human disturbance by sonic booms at sea." Masking due to background noise tends to lessen the effects of sonic booms on people aboard ship, and vibrations and other motions which would be unacceptable in buildings are commonplace on board a ship.

Direct damage to surface craft is very unlikely. During controlled experiments on monitored buildings, no sonic boom damage was observed at nominal peak pressures up to 6 psf (1). Ships and sea-going vessels are built to withstand greater stress than buildings. They must take repeated loads due to wind, waves, cargo handling, and machinery induced vibration. Hence damage to ships is very unlikely. Furthermore, given the infrequent schedule of Shuttle flights, it should be possible to provide warning to surface craft where high pressures are expected.

It is unlikely that sonic booms pose a hazard to fish or marine life. Evidence shows (2,3) that below Mach 4.5, the N-Wave reflects from the surface of the water as though it were solid land. A pressure field is set up in the water but it does not propogate and its level decays very rapidly with depth. This is shown graphically in figures 5.2 and 5.3 (from ref. 2) which compare the theoretical pressure distribution from a sonic boom with ambient acoustic pressure spectrum in the ocean. The boom pressures are greater than the background noise only over a limited portion of the spectrum. Figure 5.4 (from ref. 3) shows the rapid decay of the boom pressure as depth increases.

Tests of fish mortality were conducted using underwater explosives. These tests showed that much higher pressure levels than those of sonic booms were necessary to show appreciable fish mortality.

Theory indicates that above Mach 4.5 an acoustic wave may be transmitted from the air into the ocean. If so, the pressure field would propogate over longer distances and decay less rapidly than in the non-propagating case. Nevertheless, the pressures would still be very small compared to common hydrodynamic pressures. The maximum surface pressures expected from Shuttle associated sonic booms are about 6" of water -- the equivalent of very small wavelets or heavy spray.

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5.13 Treatment of Engine Noise

The engine noise associated with Shuttle operations was an important evaluation factor because of its environmental impact and possible effect on community acceptance of the program. In arriving at acceptable acoustic pressure levels, the Board had the benefit of NASA's long experience (over 12 years) in launching large rockets of the Saturn family. During the early planning for the Apollo program, NASA concluded that noise levels below 115 db posed no hazard to uncontrolled personnel or structures -- particularly during the brief exposure associated with a vehicle launching. Successful operation of the Apollo program substantiated this conclusion.

Available information indicates that the Shuttle launch vehicle will not significantly depart from our Saturn experience. The details of the acoustic energy spectra are expected to be somewhat different but the overall sound pressures will be of the same general magnitude. Most importantly, it does not appear that the Shuttle will go beyond the agency's earlier bases for the acquisition of real estate and the provision of buffer zones surrounding a launch site. Thus, the Board could uncover no compelling reasons for modifying the conclusions previously adopted by this agency.

The orbiter may use an air breathing jet engine system for short periods of time following reentry for return to the recovery site and also for ferry flights required by manufacture and overhaul operations. These flights will be infrequent and at subsonic velocities similar to current large jet aircraft. It is contemplated that up to four jet engines of the type being developed for the F-14/F-15 aircraft will be used on the orbiter. Four of these engines at maximum power setting at sea level static produce a maximum perceived noise level of approximately 108 db at twelve hundred feet sideline distance from the aircraft centerline. These engines have a maximum thrust level of approximately 18,000 pounds each, about half that of the jet engines used on the 747 aircraft.

5.2 Media Pollutants

5.21 Air Pollutants

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The only potential source of air pollution is the hydrogen chloride (HCl) formed in the exhaust of the solid rocket engines. This may create potentially hazardous conditions in the immediate vicinity of the launch site for a short period of time. Extensive theoretical calculations and some measurements made of solid rocket launches indicate that concentrations at ground level beneath the exhaust cloud are well below the maximum allowable 10-minute concentrations for man, and that the principal concern in the case of normal launches is the possibility of rain leeching out the HCl from the exhaust cloud in concentrations sufficient to be dangerous.

This same potential exists for the currently operational Titan III system. Standard operational procedures have been adopted that defer launches if weather conditions are such that the predictions of exhaust cloud concentrations, movements, and weather might create unacceptable conditions. The success of these precautions is demonstrated by the launching of all twenty Titan III vehicles without incident. Similar operational constraints will be imposed on space shuttle launches to eliminate the possibility of unacceptable HCl concentrations in the air or on the surface. Furthermore, the launch site evaluation includes full consideration of HCl emissions; the launch site will be laid out to ensure that any hazard potential is minimized.

In the event of on-pad fire or low-level abort of the booster with all the solid propellants consumed in the resulting fires, concentrations would be higher than for normal launches, but still within the allowable limits. Based on the demonstrated reliability of man-rated launch vehicles to date, and considering the space shuttle design, inspections, and quality control requirements, such an abnormal event is considered very unlikely.

5.22 Water Pollutants

The only possible impact on local water quality is the use of cooling water to protect flame deflectors during launch operations. Standard operating procedure calls for the containment of the cooling water until acceptable thermal levels are reached before release. This procedure will be continued at the existing sites or an equivalent will be incorporated in the design of a new facility.

5.23 Other Environmental Considerations

Operations at existing launch sites have shown no adverse effects on wild life and land use. Many citrus groves acquired by the Government at KSC have been leased to growers for continued production. The Board expects that similar precautions will be taken at the selected site to achieve similar results.

Certain social and demographic data have been collected for the existing site option. As the Shuttle program is much smaller than was the Apollo program, the social and demographic impact on the existing sites would appear acceptable. Much more data is required to fully assess the impact on a new site; nevertheless, it appears the selection of a new site could potentially disrupt all three final contending communities.

REFERENCES

1. ICAO Sonic Boom Panel, Report of the Second Meeting, October 12-21, 1970, Montreal, Canada.

2. Penetration of Sonic Boom Energy into the Ocean: An Experimental Simulation. Hydrospace Research Corporation Report NRC TR 283, June 1970 by Dr. J. F. Waters and Mr. R. E. Glass.

3. Sonic Boom in the Sea. Naval Ordnance Laboratory Report NOL TR 71-30 by R. J. Urich, Naval Ordnance Laboratory, Silver Spring, Maryland.

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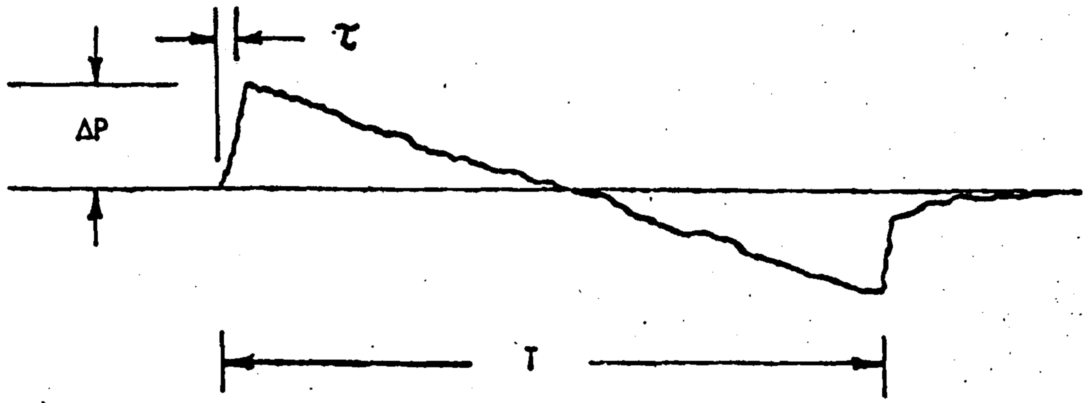
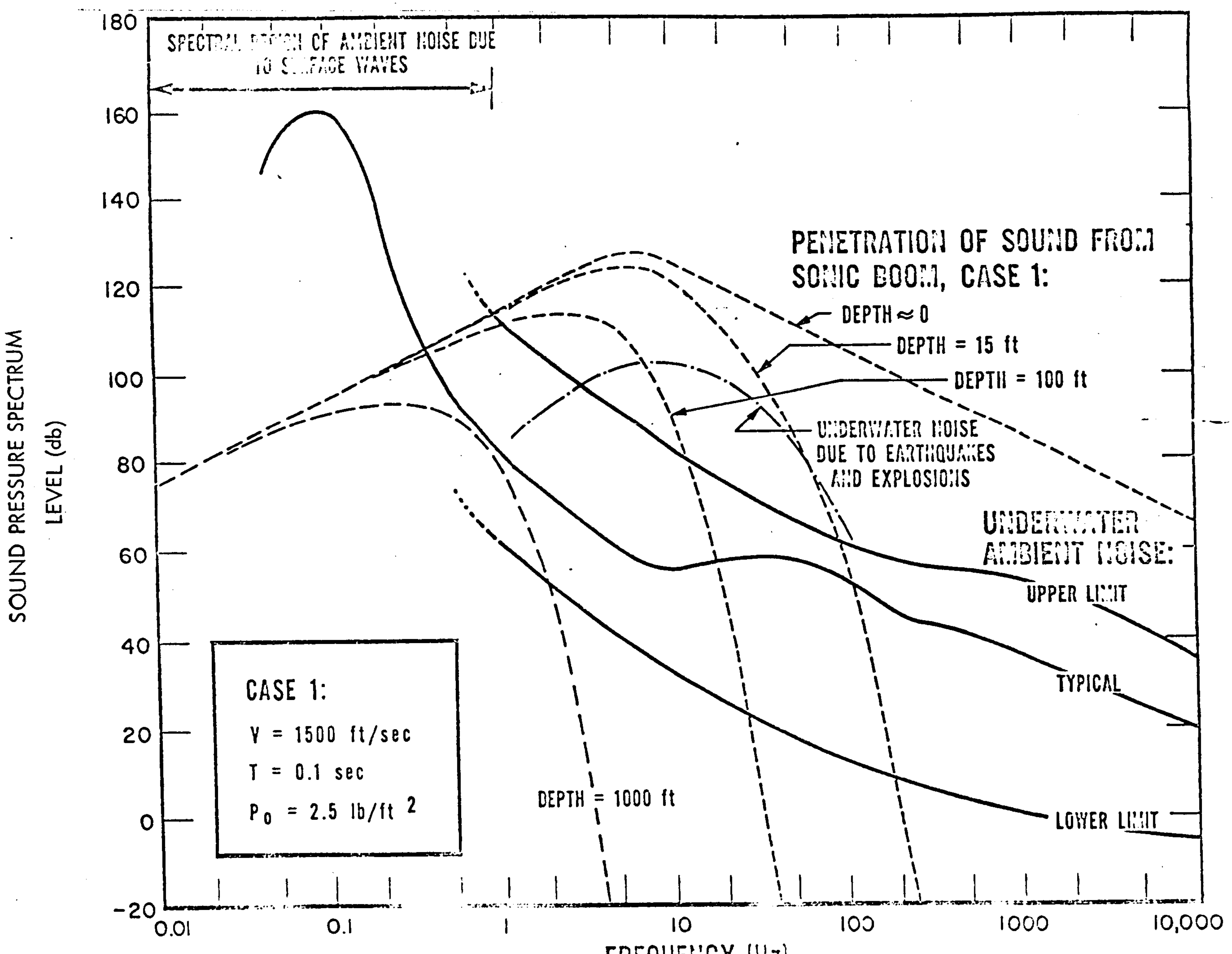
CLASSIC N WAVE ILLUSTRATION

The sonic boom disturbance, generated by the traverse of the shock wave created by supersonic flight across the surface of the ground, may be represented by the classical N wave as illustrated below.



Four parameters describe the N wave - rise time, τ; overpressure, ΔP; period, T; and the impulse under the wave. These parameters, in turn, influence the reaction of people and structures to the disturbance. The characteristics of the N wave are a function of the aircraft (weight, shape, lift and volume), its operational characteristics (velocity, altitude, flight path angle, etc.) and the atmosphere through which it propagates (turbulence, temperature, winds, etc.). The near field disturbance for aircraft has a more complex shape caused by secondary shocks. As these disturbances propagate away from the source, however, the distrubance tends toward the classical N wave distribution.

FIGURE 5.1



Comparison of Underwater Sound Pressure Spectrum Levels for Sonic Boom and Ambient Noise: Case 1

FIGURE 5.2

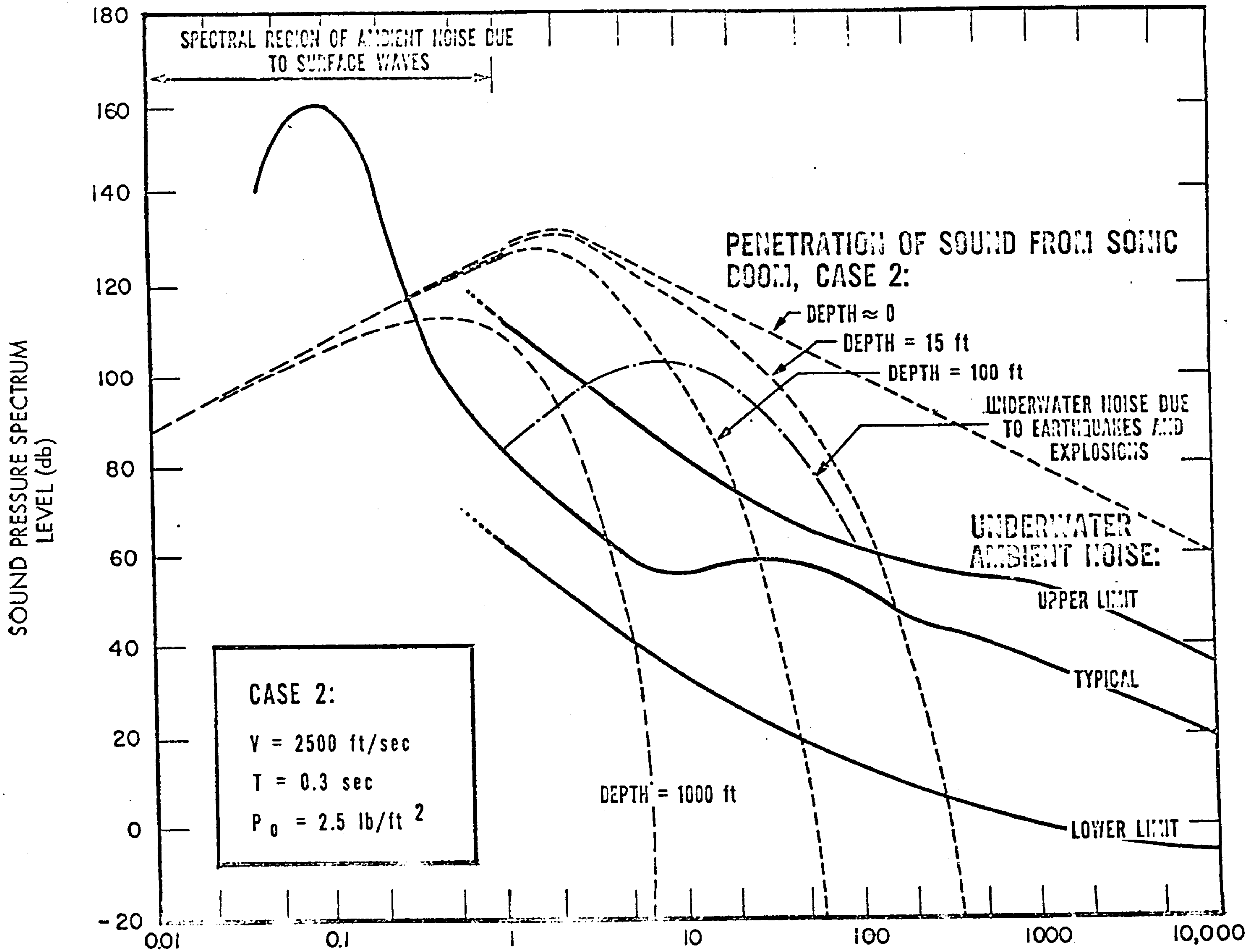

SOUND PRESSURE SPECTRUM LEVEL (db)
180
160
140
120
100
80
60
40
20
0
-20
0.01
0.1
1
10
100
1000
10,000
FREQUENCY (Hz)
SPECTRAL REGION OF AMBIENT NOISE DUE TO SURFACE WAVES
PENETRATION OF SOUND FROM SONIC BOOM, CASE 2:
DEPTH ≈ 0
DEPTH = 15 ft
DEPTH = 100 ft
DEPTH = 1000 ft
UNDERWATER NOISE DUE TO EARTHQUAKES AND EXPLOSIONS
UNDERWATER AMBIENT NOISE:
UPPER LIMIT
TYPICAL
LOWER LIMIT
CASE 2:
V = 2500 ft/sec
T = 0.3 sec
P0 = 2.5 lb/ft 2

FIGURE 5.3

Theoretical and Observed Variation of Peak Boom Level with Depth. The Theoretical Curve Is Adjusted for an Air Boom Level of +55 db.

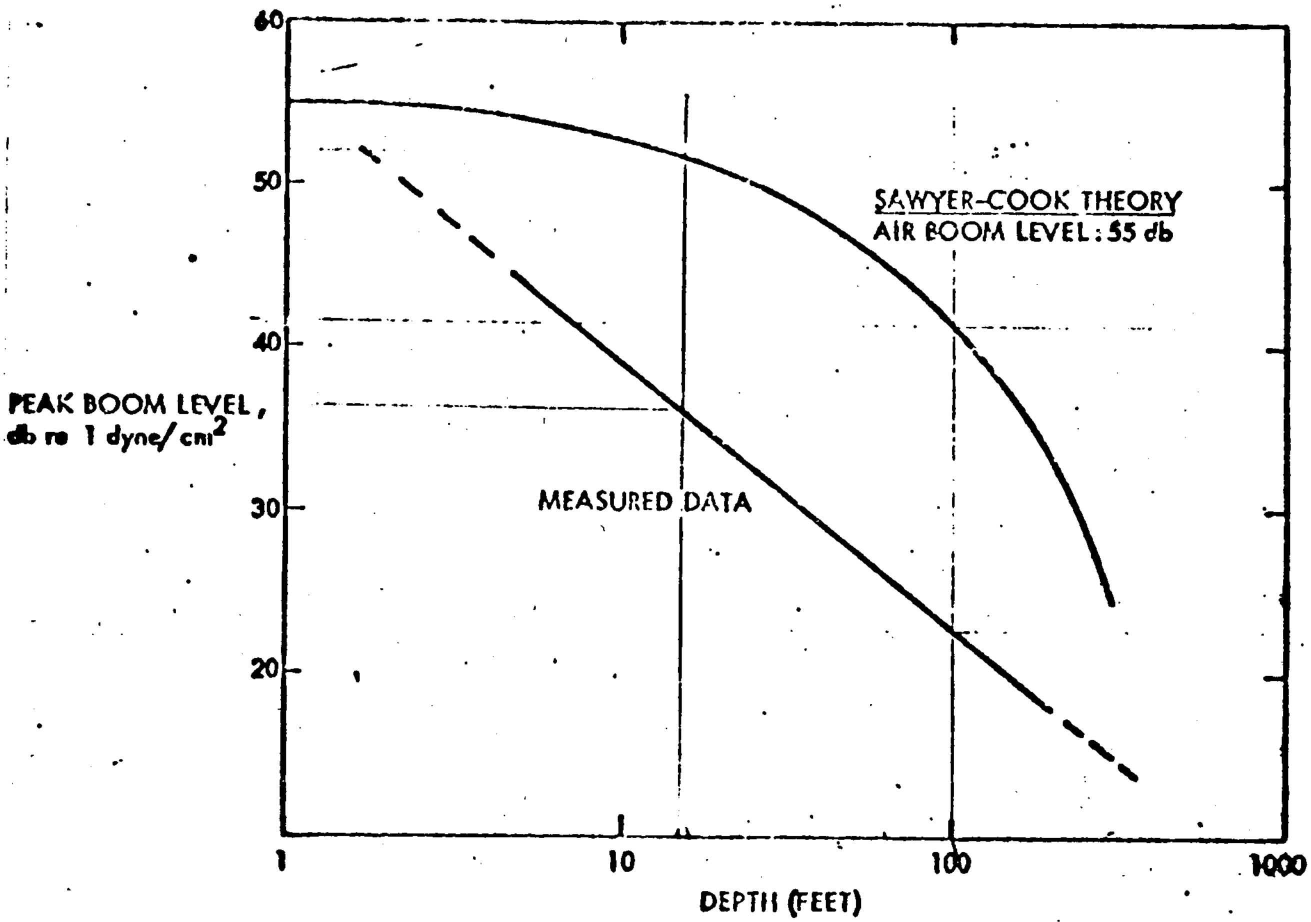


FIGURE 5.4

6. CONCLUDING REMARKS

This document has reported the results of the Board's deliberations. References and supporting information will be in agency files.

Many of the criteria considerations outlined in the Guidelines (Appendix A) are no longer at issue. For example, the OMSF addressed the question of altitude and latitude effects on vehicle performance and design. The conclusion was that, within the existing requirements for the Shuttle, the altitude advantage for rocket take-off was more than offset by orbiter landing requirements. Climate, environmental effects, and community impact are discussed earlier in this report. Possible interference with existing traffic patterns was not, however, reviewed in depth. An initial survey was made of the likely effects of booster impact zones on shipping lanes during the screening process. If a new site is selected, a thorough investigation of local air and sea traffic is warranted. This would not be an issue under the existing site option.

The cost analysis (section 4.1) discusses the phasing of funding in detail. Results show that the existing site option -- with the east coast site activated first -- leads to the lowest discounted total program cost and the lowest annual expenditures during the development period. This is because much of the necessary equipment and personnel are already in place at the east coast site. The Board could not identify any factors, at this time, which would definitely favor the west coast site for activation first.

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APPENDIX A
BOARD CHARTER AND GUIDELINES

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MH April 26, 1971

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Dr. Floyd L. Thompson
94 Alleghany Road
Hampton, Virginia 23369

Dear Dr. Thompson:

This letter will confirm your appointment as Chairman of the Space Shuttle Launch and Recovery Site Review Board. By copy of this letter, the following are designated members of the Board:

Major General Edmund F. O'Connor
Deputy Chief of Staff, Procurement and Production
Headquarters, Air Force Systems Command

Mr. Vincent L. Johnson
Deputy Associate Administrator
Office of Space Science and Applications
NASA Headquarters

Mr. Robert H. Curtin
Director, Office of Facilities
NASA Headquarters

Mr. Robert N. Lindley
Director, Engineering and Operations
Office of Manned Space Flight
NASA Headquarters

Mr. Clarence C. Gay, Jr.
Acting Director, Systems Operations
Space Shuttle Program
Office of Manned Space Flight
NASA Headquarters

Dr. Dudley G. McConnell, NASA Headquarters has been designated as Executive Secretary to the Board. Mr. Neil Hosenball, Deputy General Counsel, NASA Headquarters, will serve as legal counsel for the Board.

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In broad terms, this Board is responsible for reviewing and evaluating candidate launch and recovery sites for the Space Shuttle. Attached are guidelines which elaborate on the purpose and scope of the Board's activities. This evaluation will be used as the basis for a site selection by the Administrator. You should plan for both an oral briefing and a written report of the Board's activities and findings. In view of the importance of the selection of the launch and recovery site to other Space Shuttle program planning you should aim to complete your work at the earliest practical time.

Sincerely,

/s/

Dale D. Myers
Associate Administrator
for Manned Space Flight

Attachment

cc: AD/Dr. Low
MSFC/Dr. Rees
MSC/Dr. Gilruth, Dr. Debus/KSC
Board Members
MH/Mr. Donlan
MD/Mr. Mathews
MD-M/Mr. Gorman
X/Dr. McConnell
G/Mr. Hosenball

CONCURRENCE: MHD /s/
LEDay:nco 4/19/71 x25104

MH /s/
CJDonlan

MD-M /s/
Gorman

ADA /s/
Shapley

GUIDELINES FOR SPACE SHUTTLE LAUNCH
AND RECOVERY SITE REVIEW BOARD

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PURPOSE

The Site Review Board is charged with review of candidate launch and recovery sites, the evaluation of each site against requirements and against selection criteria, the ranking of the sites, and the presentation of these findings to the Administrator.

MEMBERSHIP

The Site Review Board will be composed of a chairman and appropriate memberships from NASA and DOD. It will be supported as required by Headquarters personnel who will assemble and analyze data and assist the board in the evaluation and report preparation.

SCOPE OF ACTIVITY

The Site Review Board will establish evaluation criteria and apply these criteria to ranking of candidate sites. The evaluation will concentrate on site requirements necessary for R&D vertical flight testing and for succeeding operational flights. The evaluation should recognize that adjustments may occur in the earliest vehicle configurations and that full operational requirements may not be initially satisfied. Both a written and oral report of the board activities and findings will be submitted to the Administrator at the earliest practicable date. In performing the evaluation, the board will draw upon new data as well as previously prepared data and will use, as needed, the resources of the Centers, Phase B Contractors, and the Parsons A/E contract. Legal counsel will be provided by Headquarters legal staff as needed.

The Site Review Board will follow Source Evaluation Board operating procedures especially with regard to the collection, safe keeping, and presentation of the data it develops.

CRITERIA CONSIDERATIONS

A. Vehicle Configuration, Mission & Payload Requirements

- Projected mission requirements - Inclinations, Azimuths, Payload Weight, Frequency

- Downrange Recovery Site - Contingency Payload Increase, Downrange Abort

- Latitude - Earth Rotation, Orbital Inclination Requirements
- Altitude - Payload Increases, Landing Considerations
- Longitude - One Revolution Abort

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B. Climate and Surrounding Terrain

- Weather, Flight Path Obstructions

C. Air Traffic Density, Sea Traffic Density

- Range Safety

D. Community Sensitivity/Environmental Considerations

- Population Density, Flight Corridors, Schools, Housing, Noise

E. Existing On-site Facilities

- Operational, Support

F. Existing Off-site Resources

- Commercial Transportation, Accessibility, Utility Capacity, Available Tracking and Data Facilities

G. Costs and Phasing of Funding for Facilities

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APPENDIX B
REVIEW BOARD CHRONOLOGY

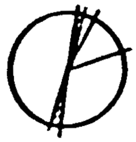
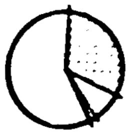
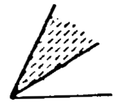
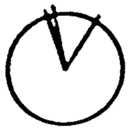
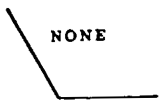
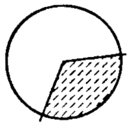
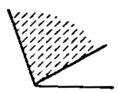
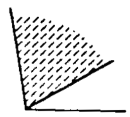
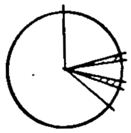
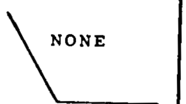
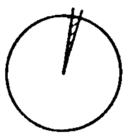
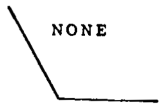
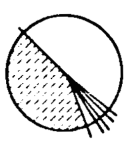
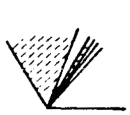
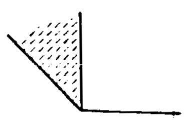
Space Shuttle Launch and Landing Site
Review Board - Chronology

Apr. 26, 1971	Formal Appointment
May 4, 1971	Board Meeting- Review of Program Planning Prelim. Mission & Site Requirements
May 26, 1971	Board Meeting Shuttle Operations Planning DoD Mission & Site Requirements
June 22, 1971	Board Meeting Review of Program Status Extension of Contractor studies to include interim expendable boosters Review of Sonic Boom Characteristics
Aug. 4, 1971	Board Meeting Report of Sonic Boom Panel
Aug. 19, 1971	Board Meeting Altitude vs latitude payload effect
Sept. 21-24, 1972	Board visit to OMSF Centers for briefings
Oct. 1971 through Dec. 1971	Board recess for duration of phase B vehicle design studies
Jan. 6, 1972	Presidential Authorization of Shuttle Program
Jan. 13, 1972	Review of Program Status Assess Future Course of Site Evaluation
Jan. 19, 1972	Board Meeting Interim Meeting with Administrator
Feb. 17, 1972	Board Meeting Performance of Booster Options Capabilities of Inland Sites
Feb. 24, 1972	Board Meeting Overflight Hazard Assessment Further Study of Inland Sites
Mar. 1, 1972	Interim Position Paper
Mar. 27, 1972	Board Meeting Results of Site Screening Implication of Booster Selection Outline of Cost Study

70	April 6, 1972	Board Meeting Results of Cost Studies Detailed Site Evaluation
71	April 10, 1972	Report to Administrator

APPENDIX C
SUMMARY DESCRIPTION OF CANDIDATE SITES

APPENDIX C
SUMMARY DESCRIPTION OF CANDIDATE SITES

SITE LOCATION	ELEVATION	LAUNCH AZIMUTHS AVAILABLE (OPERATIONAL)		AZIMUTHS TO IMPACT ZONES	INCLINATIONS AVAILABLE FROM IMPACT ZONES	MISSION COVERAGE INCLINATIONS FROM COMPOSITE AZIMUTHS	BOOSTER IMPACT ZONE CHARACTERISTICS	H[illegible]
EDWARDS AFB, CALIFORNIA 34.9° N. LAT. 117.7° W. LONG.	2,[illegible] FEET	AZIMUTHS FREE OF TOWNS IN BOOSTER IMPACT ZONES SONIC BOOM OVERFLIGHT COMPOSITE	[illegible] [illegible] [illegible] [illegible] NONE			 NONE	ROUGH & MOUNTAINOUS EXCEPT TO SOUTH INTO PACIFIC OCEAN	386.[illegible] AP[illegible] 55,[illegible]
KENNEDY SPACE CENTER FLORIDA 28.5° N. LAT. 80.5° W. LONG.	[illegible] FEET	WATER IMPACT SONIC BOOM OVERFLIGHT COMPOSITE	[illegible] [illegible] [illegible] [illegible]				ALL ZONES ARE IN DEEP WATER AREA	87,[illegible] AP[illegible] 55, (PA[illegible] W[illegible]
LAS VEGAS, NEVADA 36.1° N. LAT. 115.[illegible]° W. LONG.	4,[illegible] FEET	AZIMUTHS FREE OF TOWNS IN BOOSTER IMPACT ZONES SONIC BOOM OVERFLIGHT COMPOSITE	[illegible] [illegible] NONE			 NONE	ROUGH & MOUNTAINOUS FORESTED	4,260 APP[illegible] 55,00[illegible]
MATAGORDA COUNTY, TEXAS 28.8° N LAT. 95.6° W. LONG.	5 FEET	WATER IMPACT SONIC BOOM OVERFLIGHT COMPOSITE	082°-201° 095°-196° 085°-189° 095°-189°				ALL ZONES ARE IN DEEP WATER	PR[illegible] O[illegible] AP[illegible] 55, (PA[illegible] W[illegible]
MICHAEL/DUGWAY, UTAH 40.3° N. LAT. 112.9° W. LONG.	5,300 FEET	AZIMUTHS FREE OF TOWNS IN BOOSTER IMPACT ZONES SONIC BOOM OVERFLIGHT COMPOSITE	357° 077°-079° 100°-103° -126° NONE			 NONE	ROUGH & MOUNTAINOUS FORESTED	DUG[illegible] PRO[illegible] GRO[illegible] 842,3[illegible] LAU[illegible] OFF[illegible] GRO[illegible] APP[illegible] 55,0[illegible] AIRF[illegible] PRO[illegible]
MOUNTAIN HOME, IDAHO 43.3° N. LAT. 115.4° W. LONG.	5,000 FEET	AZIMUTHS FREE OF TOWNS IN BOOSTER IMPACT ZONES SONIC BOOM OVERFLIGHT COMPOSITE	008°-012° NONE			 NONE	ROUGH & MOUNTAINOUS NATIONAL FOREST	FOREST[illegible] CONTR[illegible] APPRO[illegible] 55,000 A[illegible]
VANDENBERG AFB(WTR), CALIFORNIA 34.6° N. LAT. 120.6° W. LONG.	375 FEET	WATER IMPACT SONIC BOOM OVERFLIGHT COMPOSITE	133°-318° 182°-295° 152°-330° 182°-295°				ALL ZONES ARE IN DEEP WATER AREAS	99,40[illegible] APPR[illegible] 55,00[illegible] (PART[illegible] WAT[illegible]

	FACILITIES									
BOOSTER IMPACT ZONE CHARACTERISTICS	LAND EXISTING / REQUIRED	PRESENT USE	SITE POPULATION	FACILITY COSTS ($ IN MILS) 2 PADS/60 LAUNCHES/YR INITIAL	ANNUAL	POPULATION LOCAL COUNTY	CONTIGUOUS COUNTIES	LABOR FORCE	U R
ROUGH & MOUNTAINOUS EXCEPT TO SOUTH INTO PACIFIC OCEAN	356,300 ACRES / APPROX. 55,000 ACRES	USAF, NASA & USA FLIGHT TEST CENTER	MILITARY 2,875 OTHER 3,744	777.1 (INCLUDES 237.1 FOR ACCESS ROADS TO IMPACT ZONE & HO TANK ASSY)	38.1	KERN 329,162	LOS ANGELES SAN BERNARDINO 7,716,147	LOCAL COUNTY 131,000 CONTIGUOUS COUNTIES 3,572,000	75% LOC CO 12,7 50% LOC CO 8,50
ALL ZONES ARE IN DEEP WATER AREA	87,880 ACRES / APPROX. 55,000 ACRES (PART OVER WATER)	APOLLO LAUNCH OPERATIONS & OTHER SPACE ACTIVITY	CIVIL SERVICE 2,744 CONTRACTOR 13,100	179.7 (113.0 FOR 2 PADS & 40 LAUNCHS PER YEAR)	30.3	BREVARD 230,006	INDIAN RIVER LAKE OSCEOLA ORANGE SEMINOLE VOLUSIA 728,054	LOCAL COUNTY 98,600 CONTIGUOUS COUNTIES 257,400	100% LOCA CO 17,00 75% LOCA CO 12,75
ROUGH & MOUNTAINOUS FORESTED	4,260,000 ACRES / APPROX. 55,000 ACRES	BOMBING GUNNERY RANGE PART IS DESIGNATED AS DESERT GAME RESERVE	NO PERMANENT POPULATION BOMBING RANGE	783.7 (INCLUDES 223.3 FOR ACCESS ROADS TO IMPACT ZONE & HO TANK ASSY.)	38.1	CLARK 273,288	LINCOLN NYE INYO 23,727	LOCAL COUNTY 121,400 CONTIGUOUS COUNTIES 15,481	100% LOCA CO 17,00 75% LOCA CO 12,75
ALL ZONES ARE IN DEEP WATER	PRIVATELY OWNED / APPROX. 55,000 ACRES (PART OVER WATER)	AGRICULTURAL OIL WELLS IN NEAR VICINITY	NO PERMANENT POPULATION ON SITE	562.2 (613.0 FOR 3 PADS & 60 LAUNCHES PER YEAR)	24.7	MATAGORDA 27,913	BRAZORIA CALHOUN CHAMBERS FORT BEND GALVESTON HARMS JACKSON VICTORIA WHARTON 2,205,838	LOCAL COUNTY 9,870 CONTIGUOUS COUNTIES 920,700	50% LOCA CO 8,500 25% LOCA CO 4,250
ROUGH & MOUNTAINOUS FORESTED	DUGWAY PROVING GROUND 842,327 ACRES LAUNCH SITE OFF PROVING GROUND / APPROX. 55,000 ACRES AIRFIELD ON PROVING GRD.	DUGWAY PROVING GROUND IS ARMY WEAPONS TEST SITE LAUNCH PADS SITUATED ON SKULL VALLEY INDIAN RESERVATION	ESTIMATED 3,500 IN LAUNCH COMPLEX AREA	725.8 INCLUDES 207.5 FOR ACCESS ROADS TO IMPACT ZONES & HO TANK ASSY.	34.8	TOOELE 21,545	SALT LAKE UTAH DAVIS WEBER 800,144	LOCAL COUNTY 10,950 CONTIGUOUS COUNTIES 253,380	75% LOCA CO 12,75 50% LOCA CO 8,500
ROUGH & MOUNTAINOUS NATIONAL FOREST	FOREST SERVICE CONTROL / APPROX. 55,000 ACRES	FOREST SERVICE	NO PERMANENT POPULATION ON SITE	832.3 INCLUDES 237.1 FOR ACCESS ROADS TO IMPACT ZONES & HO TANK ASSY.	35.6	ELMORE 17,479	ADA BLAINE BOISE CAMAS CANYON GOODING LINCOLN OWYHEE TWIN FALLS 219,730	LOCAL COUNTY 4,464 CONTIGUOUS COUNTIES 108,642	75% LOC CO 12,7 50% LOC CO 8,50
ALL ZONES ARE IN DEEP WATER AREAS	99,400 ACRES / APPROX. 55,000 ACRES (PART OVER WATER)	USAF BASE TEST LAUNCH OF IBM'S POLAR SPACE LAUNCHES	MILITARY 7,725 CIVIL SERVICE 2,372 CONTRACTOR 5,671 DEPENDENTS ON BASE 7,942	399.0 (314.0 FOR 1 PAD & 20 LAUNCHES PER YEAR)	31.6	SANTA BARBARA 264,324	SANTA MARIA SAN LUIS OBISPO LOMPOC 105,690	LOCAL COUNTY 120,000 CONTIGUOUS COUNTIES 35,000	75% LOCA CO 12,75 50% LOCA CO 8,50

COSTS (…LS) …NCHES/YR ANNUAL	POPULATION LOCAL COUNTY	 CONTIGUOUS COUNTIES	COMMUNITY LABOR FORCE	HOUSING UNITS REQ'D *	 UNITS AVAIL.	SCHOOLS ENROLLED	 NEW PUPILS *	ECONOMIC BASE	ACCESS & LOGISTICS	UTILITIES WATER GAS ELECTRIC	AIR TRAFFIC WITHIN 100 MILES
38.1	KERN [illegible]	LOS ANGELES SAN BERNARDINO [illegible]	LOCAL COUNTY 131,000 CONTIGUOUS COUNTIES 3,572,000	75% LOCATED IN COUNTY 12,750 50% LOCATED IN COUNTY 8,500	KERN COUNTY 4,141	KERN COUNTY 97,400	75% IN COUNTY 13,875 50% IN COUNTY 9,250	AEROSPACE INDUSTRY AGRICULTURE	RAIL ROAD AIR	WATER: ON BASE WELLS GAS: PACIFIC GAS & ELECT. CO. 2 EA. 34 IN. MAINS ELECTRIC: SO. CALIF. EDISON 69,000 V LINES	90,000 SCHEDULED ANNUALLY
30.3	BREVARD [illegible]	INDIAN RIVER LAKE [illegible] ORANGE SEMINOLE [illegible] [illegible]	LOCAL COUNTY 98,600 CONTIGUOUS COUNTIES 257,400	100% LOCATED IN COUNTY 17,000 75% LOCATED IN COUNTY 12,750	BREVARD COUNTY 7,218	BREVARD COUNTY 71,300	100% IN COUNTY 18,500 75% IN COUNTY 13,875	SPACE CENTER AGRICULTURE TOURISM LIMITED AEROSPACE	RAIL ROAD AIR WATER	WATER: CITY OF COCOA WELLS GAS: FLORIDA GAS TRANSMISSION CO. 23 INCH MAIN ELECTRIC: FLORIDA PWR. & LT. CO. 69,000 V LINES	40,000 SCHEDULED ANNUALLY
38.1	CLARK [illegible]	[illegible] [illegible] [illegible] [illegible]	LOCAL COUNTY 121,400 CONTIGUOUS COUNTIES 15,481	100% LOCATED IN COUNTY 17,000 75% LOCATED IN COUNTY 12,750	CLARK COUNTY 3,795	CLARK COUNTY 80,650	100% IN COUNTY 18,500 75% IN COUNTY 13,875	ORE PROCESSING MANUFAC-TURING TOURISM GAMBLING RANCHING MINING	ROAD RAIL AIR	WATER: ON SITE WELLS GAS: SO. WEST GAS CORP. NEAREST MAIN 25 MILES AWAY ELECTRIC: NEVADA PWR. CO. 138,000 V LINE	47,000 SCHEDULED ANNUALLY
24.7	MATAGORDA [illegible]	[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] WHARTON [illegible]	LOCAL COUNTY 9,870 CONTIGUOUS COUNTIES 920,700	50% LOCATED IN COUNTY 8,500 25% LOCATED IN COUNTY 4,250	MATHGORDA COUNTY 692	MATAGORDA COUNTY 8,650	50% IN COUNTY 9,250 25% IN COUNTY 4,625	OIL PRODUCTION AGRICULTURE	ROAD RAIL WATER	WATER: WELLS ON SITE GAS: 12 INCH MAIN ELECTRIC: COMM PUBLIC SERVICE CO 69,000 V LINE	17,000 SCHEDULED ANNUALLY
34.8	TOOELE [illegible]	SALT LAKE [illegible] [illegible] [illegible] [illegible]	LOCAL COUNTY 10,950 CONTIGUOUS COUNTIES 253,380	75% LOCATED IN COUNTY 12,750 50% LOCATED IN COUNTY 8,500	TOOELE COUNTY 238	TOOELE COUNTY 6,875	75% IN COUNTY 13,875 50% IN COUNTY 9,250	AGRICULTURE AEROSPACE INDUSTRY TOURISM	RAIL ROAD AIR	WATER: SPRINGS & RUNOFF RESERVOIRS GAS: MOUNTAIN FUEL SUP CO. 16 INCH MAIN ELECTRIC: UTAH PWR. & LT. CO. 69,000 V LINE	44,000 SCHEDULED ANNUALLY
35.6	ELMORE [illegible]	[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] TWIN FALLS [illegible]	LOCAL COUNTY 4,464 CONTIGUOUS COUNTIES 108,642	75% LOCATED IN COUNTY 12,750 50% LOCATED IN COUNTY 8,500	ELMORE COUNTY 207	ELMORE COUNTY 5,400	75% IN COUNTY 13,875 50% IN COUNTY 9,250	AGRICULTURAL	ROAD RAIL AIR	WATER: GROUND WATER GAS: 22 INCH LINE ELECTRIC: 287,000 V LINE	4,000 SCHEDULED ANNUALLY
31.6	SANTA BARBARA [illegible]	SANTA MARIA SAN LUIS OBISPO [illegible] [illegible]	LOCAL COUNTY 120,000 CONTIGUOUS COUNTIES 35,000	75% LOCATED IN COUNTY 12,750 50% LOCATED IN COUNTY 8,500	SANTA BARBARA COUNTY 3,097	SANTA BARBARA COUNTY 71,500	75% IN COUNTY 13,875 50% IN COUNTY 9,250	TOURISM AGRICULTURE 125 MILES TO LOS ANGELES INDUSTRIAL COMPLEX	RAIL ROAD AIR WATER IF MARINE FACILITY ADDED	WATER: ON-BASE WELLS GAS: PACIFIC LIGHTING SERVICE CO. 10 INCH MAIN	25,000 SCHEDULED ANNUALLY

*PERCENTAGES ARE OF TOTAL

	CLIMATE & ENVIRONMENT				OTHER		
IR TRAFFIC WITHIN 100 MILES	WEATHER	HAZARDS & NUISANCE	ENVIRONMENT & ECOLOGY CATEGORY	 MAJOR CHANGE	UNIVERSITY SUPPORT	RECREATION	FUTURE DEVELOPMENT
90,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 0 CEIL. 2000 FT.-VIS. 3 MI. 96.0 TORNADOS-10 YRS. 0 THUNDERSTORMS-D/YR 10 MAX. WIND RECORDED 63 mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 2 TEMP. BELOW 32°F. D/YR. 10	PROPOSED LAUNCH SITE ON EXISTING RESERVATION ENGINE NOISE WILL NOT SERIOUSLY AFFECT TOWNS SONIC BOOM (FOCUSING) WILL HIT LOS ANGELES ON SOUTHERLY LAUNCH & OTHER LESS POPULATED	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO NO NO NO NO NO NO NO NO NO YES-SRM EFFLUENT	UNIV. OF SO. CALIFORNIA CALIFORNIA INSTITUTE OF TECHNOLOGY UNIV. OF CALIFORNIA LOS ANGELES OTHERS	OUTDOOR SPORTS CAMPING HUNTING MAJOR LEAGUE BASEBALL & FOOTBALL THEATER	NEW LOS ANGELES INTERNATIONAL AIRPORT MAY CAUSE AIR TRAFFIC INTERFERENCE. POSSIBLE COMMUNITY ENCROACHMENT FROM SOUTH
40,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 9 CEIL. 2000 FT.-VIS. 3 MI. 95.0 TORNADOS-10 YRS. 16 THUNDERSTORMS-D/YR. 80 MAX. WIND RECORDED 88mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 13 TEMP. BELOW 32°F. D/YR. 4	L. C. 39 REMOTE FROM POP. ENGINE NOISE SIMILAR TO APOLLO SONIC BOOMS (FOCUSING) OVERWATER NO FIXED POP. ON WATER	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-AIRFLD NO NO NO NO NO NO NO NO YES-SRM EFFLUENT	UNIV. OF FLORIDA UNIV. OF MIAMI UNIV. OF SO. FLORIDA OTHERS	FISHING HUNTING GOLF WATER SPORTS	NONE ADVERSE TO SPACE SHUTTLE DISNEY WORLD HAS INCREASED TOURISM
47,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 0 CEIL. 2000 FT. - VIS. 3 MI. 99.4 TORNADOS - 10 YRS. 0 THUNDERSTORMS-D/YR. 20 MAX. WIND RECORDED 74mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 0.9 TEMP. BELOW 32°F. D/YR. 42	PROPOSED LAUNCH SITE ON EXISTING BOMBING RANGE ENGINE NOISE WILL NOT SERIOUSLY AFFECT TOWNS SONIC BOOMS (FOCUSING) WILL HIT NUMEROUS TOWNS FOR NORTHERLY LAUNCHES	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-TOWWAY NO NO NO NO NO NO NO NO YES-SRM EFFLUENT	UNIV. OF NEVADA 250 MILES AWAY AT RENO	OUTDOOR SPORTS THEATER GAMBLING HUNTING FISHING BOATING	NONE ADVERSE TO SPACE SHUTTLE POSSIBLE INTERFERENCE WITH ADJACENT AEC TEST ACTIVITIES
7,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 3 CEIL. 2000 FT. - VIS. 3 MI. 84.0 TORNADOS - 10 YRS. 16 THUNDERSTORMS-D/YR. 40 MAX. WIND RECORDED 110mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 4.0 TEMP BELOW 32°F. D/YR. 6	PROPOSED LAUNCH SITE ALONG GULF COAST WITH INTRA-COASTAL WATERWAY INTERVENING ENGINE NOISE WILL NOT SERIOUSLY AFFECT TOWNS SONIC BOOMS (FOCUSING) OVER WATER	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-L. C. YES YES NO YES NO NO NO NO YES-SRM EFFLUENT	UNIV. OF HOUSTON RICE UNIV. BOTH 65 MILES AWAY	BOATING FISHING OUTDOOR SPORTS 65 MILES TO HOUSTON MAJOR ATHLETIC EVENTS	NONE ADVERSE TO SPACE SHUTTLE LOCATED ON EDGE OF PRODUCING OIL FIELD
44,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 0 CEIL. 2000 FT. - VIS. 3 MI. 96.0 TORNADOS - 10 YRS. 0 THUNDERSTORMS-D/YR. 35 MAX. WIND RECORDED 71mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 0.6 TEMP. BELOW 32°F. D/YR. 143	PROPOSED LAUNCH SITE REMOTE FROM POPULATION CONCENTRATION ENGINE NOISE WILL NOT SERIOUSLY AFFECT TOWNS SONIC BOOMS (FOCUSING) WILL HIT NUMEROUS TOWNS ON EASTERLY LAUNCHES	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-TOWWAY YES YES NO YES YES NO NO NO YES-SRM EFFLUENT	BRIGHAM YOUNG UNIV. UNIV. OF UTAH UTAH STATE UNIV. WEBER STATE COLLEGE	OUTDOOR SPORTS HUNTING FISHING CAMPING THEATER	NONE ADVERSE TO SPACE SHUTTLE
4,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 0 CEIL. 2000 Ft. - VIS. 3 MI. 91.2 TORNADOS-10 YRS. 4 THUNDERSTORMS-D/YR. 19 MAX. WIND RECORDED 88mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. .65 TEMP. BELOW 32° F. D/YR. 185	PROPOSED LAUNCH SITE REMOTE FROM POPULATION CONCENTRATION SONIC BOOMS (FOCUSING) MAY HIT TOWNS ON NORTHERLY LAUNCHES	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-L. C. YES YES YES YES NO NO NO NO YES-SRM EFFLUENT	BOISE STATE COLLEGE	OUTDOOR SPORTS HUNTING FISHING THEATER	NONE ADVERSE TO SPACE SHUTTLE
25,000 SCHEDULED ANNUALLY	HURRICANES (1938-1965) 0 CEIL. 2000 FT. -VIS. 3 MI 95.0 TORNADOS-10 YRS. 0 THUNDERSTORMS-D/YR. 5 MAX. WIND RECORDED 80mph CORROSION-CHLORIDE IN PRECIP. lbs/acre/yr. 3.0 TEMP. BELOW 32° F. D/YR. 2.3	PROPOSED LAUNCH SITE ON OCEAN COAST NO POPULATION CONCERTRATION CLOSE ENGINE NOISE SIMILAR TO PRESENT LAUNCHES SONIC BOOMS OVER WATER	MOD. OF REGIME LAND TRANSFORM'D INDUSTRIAL PROCESS'G TRAFFIC CHANGES WASTE DISPOSAL LAND USE FLORA FAUNA CULTURAL FACTORS BIOLOGICAL CONDITIONS PHYSICAL & CHEMICAL	NO YES-TOWWAY NO NO NO NO NO NO NO NO NO	UNIV. OF CALIFORNIA SANTA BARBARA ALLAN HANCOCK COLLEGE	OUTDOOR SPORTS HUNTING FISHING BOATING	NONE ADVERSE TO SPACE SHUTTLE

SUMMARY OF STANDARD SITE DESCRIPTIONS
TABLE C-1